Sustainable Schools: Beyond Measure?

Michael D Roberts

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Abstract

This PhD research project has examined four newly built secondary schools in Leicester, England that were procured through the UK Government's Building Schools for the Future (BSF) programme (2003-2010).

The research strategy has adopted a mixed-methods approach using a range of quantitative and qualitative data. The principle aim was to establish a theoretical framework for Sustainable Development which could then help to shape the analysis. Five specific dimensions were identified as a result of an extensive literature review (Education [A], Community [B], Environment [C], Technology [D] and Economics [E]). It was also important to consider the dynamic nature of a school in relation to the study's overarching question; 'Sustainable Schools; Beyond Measure?' In this regard, a "systems" approach was selected, which in turn led to the identification of three further levels of analysis (Inputs [1], Processes [2] and Outcomes [3]).

Five objectives were then identified, helping to instruct the direction of the research activities. Firstly, the BSF procurement mechanism had to identify a private sector partner to rebuild the 16 secondary schools in Leicester over a 10 year period. This was time consuming and did not include energy efficiency as part of the selection process. Secondly, the commissioning of the four phase one buildings prior to occupancy was not sufficiently thorough. As a result, multiple operational problems were encountered post-occupancy by the Facility Management (FM) Provider. Thirdly, when the utility data was examined, the schools were not performing efficiently around their schedule of activities. When the Building Management Systems (BMS) were subsequently re-commissioned, timer settings were adjusted, resulting in substantial carbon and energy savings. Fourthly, when the staff completed an occupancy satisfaction survey, the results identified numerous comfort problems which could be linked to the heating, ventilation and air-conditioning systems (HVAC). Finally, when the researcher looked back at the past 10 years of educational statistics (2002-2012), it was clear how attainment, based on GCSE results, had dramatically improved following the move into the new buildings in September 2009.

In order to draw out new insights from this wide spectrum of data, a matrix was developed, helping to organise the information in a systematic way. More generally, it is hoped this approach will promote a more intricate understanding about the way Sustainable Development can be integrated into future procurement mechanisms, building regulations and education policy.

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List of Contributors

This is a list of individuals who to varying degrees contributed to, or supported the research.

* Indicates those individuals who no longer hold their original positions as listed below.

Adrian Leaman	POE Specialist, Founder Usable Buildings Trust (UBT)
Roderic Bunn	POE Specialist, BSRIA Building Consultant
Chris Watson	POE Specialist, and Architect
Professor Mark Lemon	DMU (2011-2013) Primary Supervisor – 5 Capitals.
Dr Fiona Charnley*	DMU (2009-2011) Primary Supervisor – Systems Thinking.
Dr Neil Brown	DMU, Secondary Supervisor – Engineer.
Stewart Mann*	DMU, Building Services Engineer, Consultant.
Andrew Harris	M&E engineer, consulting with LCC-BSF projects
Sam Roberts	LCC-BSF Project Team Administrator/Manager
Gurnek Singh	LCC-BSF Project Team Administrator
Prakash Patel	LCC, Energy Manager
John Garratt	LCC, Planning and Property, Children & Young People's Services
Jaz Curry	LCC, 'Transforming the Learning Environment' (TLE) Manager
Jai Augi	LCC, Graduate Intern, administrative support
Lez Bullwer	LCC, Data and Statistics Manager (school statistics)
Jay Hardman	LCC, Research and Intelligence Manager (schools statistics)
Amrita Dasgupta	KTP Associate / Sustainability and Low Carbon Building Officer
Dr Richard Kilpatrick	Researcher, Heriot Watt University
Ann Finlayson	Sustainability and Environmental Education (SEEd) Director
Dr Jason Palmer	Research Fellow, Cambridge University,
Professor W. Preiser	Architect and POE/BPE expert with 40 years experience
Private Sector Partners	Personnel at the Contractors, FM Provider and Architects
Staff at the four schools	Interviewees and questionnaire participants

Glossary

* Programmes, Departments, Agencies or Quangos which have been cancelled or disbanded.

BECTA*	British Educational Communications and Technology Agency
BeMS	Building Energy Management System
BMS	Building Management System
BSFI	Building Schools for the Future Investments
BIS	Dpt. for Business Innovation and Skills (works with PfS)
BRE	The Building Research Establishment
BREEAM	The BRE-Environment Assessment Method
BSF*	Building Schools for the Future (2003-2010)
BRSIA	The Building Research Services and Information Association
CABE*	Commission for Architecture in the Built Environment
CARB	Carbon Reduction in Buildings
CDA	Client Design Advisor (CABE)
CRC	Carbon Reduction Commitment
CLG	Dpt. for Communities and Local Government
CIBSE	Chartered Institute of Building Services Engineers
CPD	Continued Professional Development
DEFRA	Department for Environment, Food and Rural Affairs
DfE	Department for Education
DfES	Department for Education and Skills
D&B	Design and Build
DBFO	Design, Build, Finance and Operate
DCSF*	Department for Children Schools and Families
DEC	Display Energy Certificate
DQI	Design Quality Indicator (part of CABE assessments)
DfES	Department for Education and Skills
ECM	Every Child Matters (Government Report)
ECFM	Every Child's Future Matters

EPC	Energy Performance Certificate
EPSRC	Engineering and Physical Sciences Research Council
FM	Facilities Management
FSM	Free School Meals
FBC	Final Business Case
FM Provider	Facilities Management Provider
HVAC	Heating, Ventilation, and Air Conditioning Technologies
ICT	Information Communication Technologies
ITCD	Invitation to Continue in Dialogue
ITPD	Invitation to Participate in Dialogue
KPI	Key Performance Indicator
LCC	Leicester City Council
LZC	Low to Zero Carbon (technology)
LA	Local Authority
LMEC	Leicester Miller Education Company
LEP	Local Education Partnership
M&E	Mechanical and Electrical
MBE KTN	Modern Built Environmental Knowledge Transfer Network
MLE	Managed Learning Environment
MUGA	Multi Use Games Area
NAO	National Audit Office
OJEU	Official Journal of the European Union
OBC	Outline Business Case
PEET*	Pilkington Energy Efficiency Trust (PhD Sponsors)
PfS*	Partnership for Schools (created by DCSF)
POE	Post Occupancy Evaluation
PCP	Primary Capital Programme
PFI	Private Finance Initiative
PPP	Public Private Partnership
PSP	Private Sector Partner
PUK*	Partnerships UK (worked with PfS)
RIBA	Royal Institute of British Architects
R&D	Research and Development

SBC	Strategic Business Case
SEN	Special Educational Needs
SPA	Strategic Partnership Agreement
SDC	Sustainable Development Commission
TLE	Transforming the Learning Environment
VLE	Virtual Learning Environment
VfM	Value for Money

Chapter 1 Introduction

This chapter introduces the reader to the "macro" challenges set out by Climate Change and a brief discussion of Sustainable Development as a global response strategy. The environmental impact from the built environment and the construction sector is then considered, along with a short description of the Building Schools for the Future (BSF) programme. Finally, the inductive nature of the research methodology has given rise to an overarching aim, supported by a series of objectives. Finally a mind-map has been created which links together the important thematic and operational elements of the research.

1.1 Climate Change and Sustainable Development

The basic science underpinning Global Warming is typically referred to as the 'green house effect'. This means that greenhouse gases which make up the atmosphere such as water vapour, carbon dioxide, methane and nitrous (etc) oxide act like a blanket, helping to insulate the earth. In May 2013, NASA[1] confirmed that the earth's carbon dioxide level had reached 400 parts per million. To put this in context, when geochemist Charles David Keeling began recording background levels of CO_2 in 1958, the carbon dioxide level at the time was 315 parts per million. Over the course of 50 years, a rise of 27% has now caused alarm among scientists and more recently politicians. But does this automatically translate into rising temperatures?

Addressing this question, it is important to consider the history of events over the last 400 years. The Industrial Revolution began in 1750 and has transformed the world. As a matter of fact, global CO_2 emissions are now approaching 7 billion tonnes per year and rising rapidly (Stern, 2006). More recently, rising emissions associated with transport and electricity highlight the way our changing behaviour impacts global emissions. Analysis of electricity consumption in schools further supports this increasing dependency on electricity following the electronic revolution and society's reliance on the internet as the primary source of information.

[1] http://climate.nasa.gov/news/916

In 1987, the United Nations World Commission on Environment and Development presented their report which set out a new vision for the world based on the principles which sustainable development has come to define. This landmark report famously defined the term sustainable development as, '*development which meets the needs of the present without compromising the ability of future generations to meet their own needs'* (p.43) whilst identifying three fundamental "topics",

Social: Education, Health, Poverty, Housing, Employment, Communities...
Environmental: Climate Change, Resources, Construction, Ecosystems, Habitats...
Economic: Profitability, Employment, Productivity, Infrastructure, Transport...

Sometimes referred to as the 'Three Pillars' of sustainability or the 'Triple Bottom Line', this basic model of sustainable development represents the most common definition. Satisfying each theme across the range of sub-themes helps to deconstruct its meaning so that a more practical set of problems can be defined and resolved. The principle interest of the present research considers the importance of school buildings in helping to support each pillar of sustainability.

Looking beyond the Brundtland Report (1987) for further evidence of the expanding awareness of Sustainable Development, with economic growth driving up global energy demand, in 1992, 178 countries signed the Framework Convention on Climate in Rio de Janeiro. At this summit, governments agreed that Climate Change was a global threat to humanity. What emerged was a realisation that the solutions would need to reflect both a top-down and bottom-up approach. On the one hand governments would need to set ambitious national targets to reduce their emissions, the "macro" challenges, whilst on the other hand, a localism agenda would need to promote a grass-roots movement where communities would come together to address the "micro" challenges.

Moving on, by 1997 the Kyoto Protocol was set up to create an international contract which restricts the amount of emissions countries are allowed to produce. This was a legal commitment selecting 1990 as the baseline year upon which performance would be compared. Taking into account the historical activities of post-industrialised countries like Britain, the protocol recognised that targets would need to reflect these inequities. In total, 38 countries agreed to the terms set out by this contract.

By 1999, the UK Government had created their Sustainable Development Strategy which brought together national, regional and local policy (HM Government, 1999). Procurement would become one of many mechanisms to drive forward the required efficiency savings set out in the Energy White Paper (DTI, 2003c) which required emissions to fall by 60% by 2050 based on 1990 levels.

Whilst economists continue to be concerned about the cost of de-carbonising the economy, in 2006, the Stern Review examined the potential economic effects of climate change which included the role the built environment would play. At the same time, the Department for Environment, Food and Rural Affairs (DEFRA, 2006) published a report which discussed the importance of procurement in relation to sustainable outcomes. Their general conclusions emphasize how a proportional response to the potential threat of climate change requires a long term strategy to be developed. Indeed, by 2008, the reduction target of 60% had now risen to 80%, after which time the Climate Change Act became law on the 26th November 2008.

Furthermore, the IPCC (2007a) identified the built environment as one of the main global sectors where sizable efficiency savings (up to 29%), could be achieved by 2020. In the UK the Education sector was identified as a possible target where substantial savings could be made. At the same time, the BSF programme was designed to address the ageing infrastructure in an effort to raise attainment and regenerate communities. Bringing these two imperatives together has thus created the impetus for a new idea – Sustainable Schools.

1.2 School Buildings and the BSF Programme

In the UK buildings make up 45% of total energy used. Breaking this statistic down further, 64% is from housing, 9% from industrial buildings and 27% from offices (Action Energy, 2002). School buildings produce about 2% of greenhouse gases, which equates to 15% of all public sector emissions (DCSF, 2010). From a different perspective, the education sector produces around 9.4 million tonnes of CO_2 per year of which 3.5 million tonnes is directly related to building usage (DCSF, 2010).

Schools also provide the social opportunities to promote sustainable development throughout the community,

> *"Schools are there to give children the knowledge and skills they need to become active members of society. Many children are rightly worried about Climate Change, global poverty and the impact of our lifestyles. Schools can demonstrate ways of living that are models of good practice for children and their communities. They can build sustainable development into the learning experience of every child to encourage innovation and improvement" (Alan Johnson, DCSF, 2007)*

The Building Schools for the Future (BSF) programme was a £45 billion infrastructure project designed to rebuild or refurbish every secondary school in the country over a 15 to 20 year period. To help create a new generation of "low-energy" schools, a further £110 million was set aside for particular projects in the second and third wave of BSF schools. This extra funding would equate to approximately £50/m² or £500,000, based on a school with a floor space of 10,000m². Moreover, these projects would also be judged according to the normalised (per m²) performance target of 27 kg CO_2/m² (equivalent to a 60% reduction). At the same time, the Department for Children Schools and Family's (DCSF, 2010) had now proposed that all new build schools should aim to be "zero-carbon" by 2016.

More generally, the BSF programme was designed to upgrade the estate after many decades of neglect. Capital funding for investment in school building in 1996/1997 was £683 million. Ten years later this had risen tenfold to around £7 billion as a result of the BSF programme. Wilkinson (2002) identifies the age of the existing estate, highlighting the fact that only 14% of existing schools were built in the last 25 years. Educational Transformation has also emerged as a notion which places ICT at the heart of learning. Given that 30% of the existing estate is more than 50 years old (Wilkinson, 2008), advancements in wireless low-energy ICT may allow refurbishment projects to be become more straight forward. At the same time, architectural knowledge will need to evolve at an equal pace to ensure school buildings are fit-for-purpose in the 21st century. This will also mean creating flexible and adaptable spaces as and when pedagogies and technologies move forward.

The BSF programme was therefore created to rebuild or refurbish all 3,500 secondary schools across England and Wales. Private finance in the form of PFI contracts would provide the mechanism through which to fund this infrastructure programme, with Partnerships for Schools (PfS), a non departmental public body, providing the administrative support for local authorities.

Interestingly, whilst PFI was originally an idea developed by the conservative party, the fact that its use enables the exchequer to control inflation and overcome a lack of public funds makes its continued adoption increasingly attractive. Moreover, it should also be noted how PFI investments only appear on the government's public borrowing balance sheets when the term of the contract expires, typically 25 years. Whilst this may seem like a risky strategy, advocates of PFI may argue its purpose is to create jobs in the private sector, which in turn helps to generate more tax and support economic growth.

It was recommended that 50% of projects be new build, 35% major refurbishment, and 15% minor refurbishment (DfES, 2005a). Furthermore, the new build projects would be expected to adopt the standard BSF-PFI contract on the basis this would deliver better value for money. To put BSF in context with the total budget for education, estimated to be around £5 billion for 2005, £2 billion was assigned to BSF projects. By 2010, total expenditure for education had risen to approximately £9 billion. However, when the new coalition came to power in 2010, the BSF programme was cancelled on the grounds that it was too bureaucratic and unaffordable given the present economic conditions (James, 2011). When finally the BSF investment comes to a close, the James Report calculates that 132 new build schools would have been procured using PFI contracts. The true legacy of BSF will therefore depend on collecting a range of data about the performance of these schools so future building projects can be delivered more effectively.

1.3 Sustainable Schools

During this period from 2003 to 2010, the Department for Children, Schools and Families (DCSF) was developing a framework titled, Sustainable Schools. This later became the 8 Doorways Framework and represents a self-assessment tool box which schools can employ in order to promote greater awareness about the environment. This would also contribute to aspects of the curriculum as part of a wider strategy to embed the principles of sustainable development into main stream education. Likewise Ofsted has published many reports during this period where "sustainability" was the focus of their considerations. More often than not, they identified how the culture of secondary schools found it more difficult to embed the principles associated with sustainable development into their activities.

At the same time a number of other government departments were also promoting the benefits of "sustainability" in schools, albeit from a more financial perspective. The 2006 DEFRA report, *Procuring the Future: Sustainable Procurement National Action Plan,* identifies BSF schools as a priority area and recommended that the DCSF and HM Treasury work together to ensure that new-build school developments meet the required standards. At the same time, Partnerships for Schools was defining sustainability as a 'long term, whole-life project' (PfS, 2007, p.12).

The House of Commons also published a report (2007) "Sustainable Schools: Are we building schools for the future?" which addressed the following concerns,

> "*... As well as being a project to improve radically the fabric of school buildings and provide massive investment in ICT, it [BSF] has been explicitly designed to transform the educational experiences of pupils and, more recently, to embed sustainability" (p.3)*

Given the selective nature in which Sustainable Development is both defined and applied, the existing research favoured the Five Capitals framework. Indeed, by discriminating between Natural Capital, Human Capital, Social Capital, Manufactured Capital and Financial Capital, this particular model of sustainable development has been synthesized with the BSF programme to produce figure 1.

Figure 1. Applying the Five Capitals to the BSF programme

To structure and guide the research, the aim and objectives have been identified.

AIM: To develop a conceptual model for “Sustainable Schools”.

Objective 1: To better understand how the BSF procurement mechanism may have enabled or inhibited the development of “low-energy” buildings.

Objective 2: To better understand how “building commissioning” links to energy efficiency (objective 3) and occupancy satisfaction (objective 4).

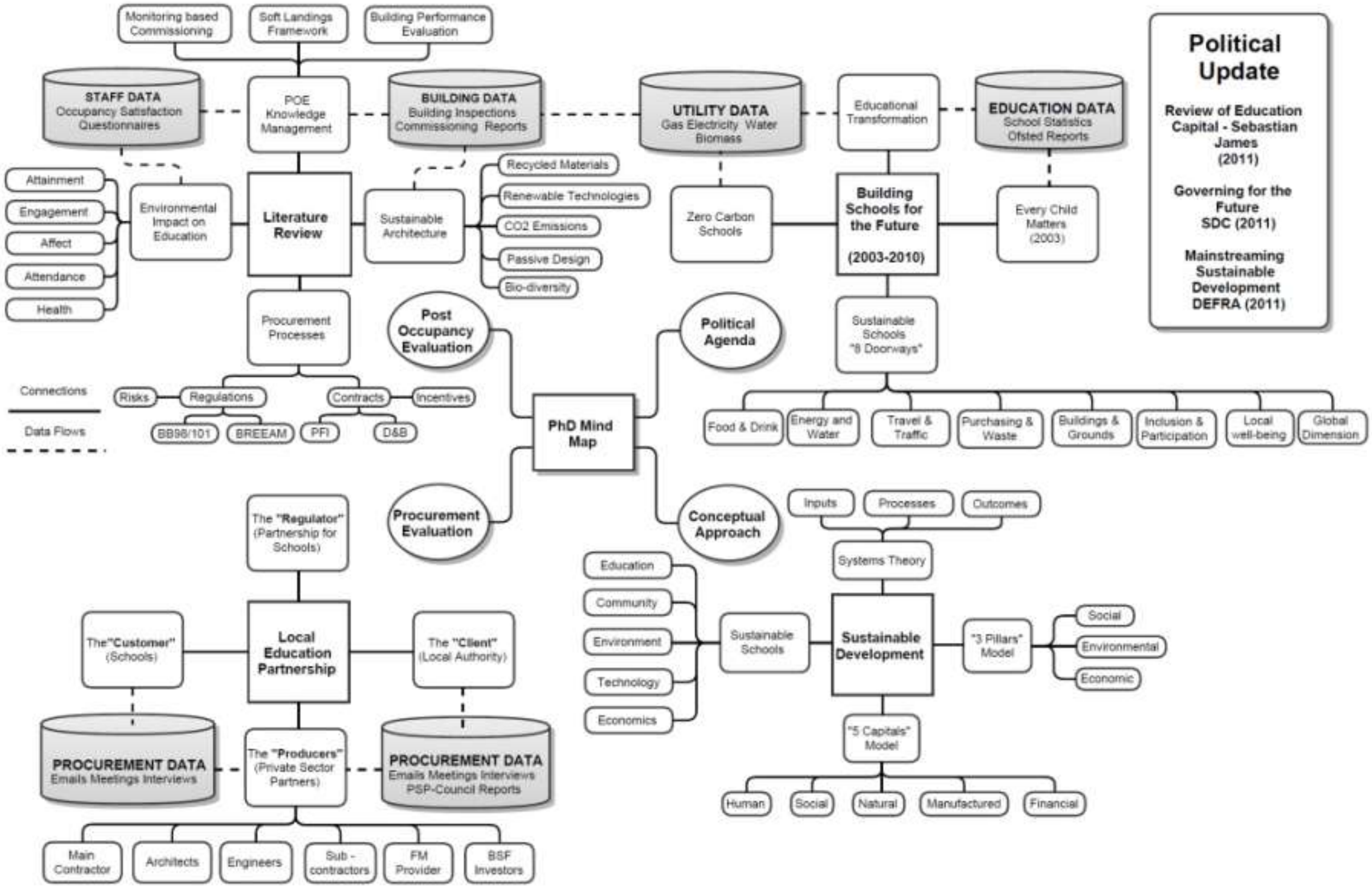
Objective 3: To carry out a detailed energy analysis of utility data.

Objective 4: To carry out a staff occupancy satisfaction survey.

Objective 5: To better understand how “Educational Transformation” can be defined and measured within BSF schools.

On the following page a detailed mind-map has been created which acts as an illustrative guide, helping the reader to navigate and connect together the project’s major themes and elements.

1.4 PhD Mind Map



Chapter 2 Literature Review

This chapter describes in detail the literature which supports the various topics which the mind map has identified. As the literature converges around three central issues; Construction, Education and Sustainability, the literature review attempts to highlight the existing deficiency in knowledge which links these topics. This in turn helps to justify the project's overarching aim - to develop a model or framework which captures the systemic and inter-dependent nature of a school, its building, and the community it serves.

2.1 Post-occupancy Evaluation (POE)

Post-occupancy evaluation (POE) is broadly speaking the most common term used to describe the process of investigating building performance both in the United Kingdom and throughout the world. The origins of POE in the UK emerged from the trend towards science-based building in the 1950s and 1960s (Bordass & Leaman, 2005). With the need to evaluate the quality of service and productivity of architectural practices, the Royal Institute of British Architects came up with its plan of work for design team operation in 1963. Published in The Architect and his Office (RIBA, 1962), architects were seen to be in 'retreat'. In 1965 however, RIBA published its first Handbook which included in its Plan of Work, Stage M: ***Feedback***.

RIBA however decided to withdraw Stage M from its publication (RIBA, 1973), reportedly because architects did not feel they could afford the additional costs associated with post-occupancy evaluations. More recently RIBA has taken the view that the biggest improvement to be made in customer focus is in systematizing feedback and instituting post-occupancy evaluation. Bordass and Leaman (2005) remind us however,

> '... *it is still rare for architects to be involved in routine feedback activities*' *('Assessing Building Performance', 2005, p.73)*.

In 1994 the UK government elected to fund a new area of research which focused specifically on newly built buildings of technical interest. The team were made up from members of the Chartered Institute of Building Services Engineers (CIBSE). This project was labelled the **P**ost-occupancy Review Of Buildings and Engineering', aka "PROBE". Between 1995 and 2002 they conducted 20 POEs on buildings of technical interest including the Queens Building (here) at De Montfort University, and developed a tool box of new evaluation techniques.

In North America, studies of buildings appeared in the late 1960s looking at university dormitories. While not called post-occupancy evaluations, these studies adopted a systematic approach looking specifically at the building users' perspective. In addition, these studies unlike the ones proposed by RIBA, were conducted by researchers typically within schools of architecture who were developing the newly emerging discipline we now refer to as 'Environmental Psychology'. Indeed, Canter (1970), at the very first conference of environmental psychology suggests,

> *'... in order to develop an understanding of people's interaction with their environment it is necessary to work towards a coherent body of scientifically established knowledge'.(p.5)*

However, practitioners often claim that too much research attention considers the intangible concerns such as individual psychology (Bordass and Leaman, 2005), whereas POE should be more concerned with collecting data routinely so the results can connect swiftly to the design and construction phases. For this reason, Canter (1984) remarks,

> *'... operating from outside the design process… POE can do very little to influence the use of existing buildings and probably even less to inform future building designs'. (p.43)*

Interestingly, Herb McLaughlin, the author of the first publication in 1975 to include the term "POE", advocates that POE needs to become an activity as part of an architect's contractual responsibility. Interestingly, the RIBA Research Steering Group according to Duffy and Hutton (1998), suggest,

> *'... perhaps the most significant development in architectural research over the last 20 years has been the rise, particularly in the US, of post-occupancy evaluation'. (p.191)*

From a historical and chronological perspective, table 1 below sets out the major milestones over a 40 year period which also demonstrates the variety of topics which relate to building performance (energy, comfort, costs, productivity etc).

Table 1. The History of POE Research

Year	Author(s)	Building Type	Contribution to the field
1967	Van der Ryn S. Silverstein	Student Dormitories	Environmental Analysis; Concepts and methods
1968	Manning	Offices & Schools	Comprehensive building appraisal
1968	Sanoff	Any facility type	"Evaluation Techniques for Designers" – first monograph on POE
1969	Preiser	Student Dormitories	Environmental performance profiles; correlation of subjective and objective performances measures
1971 *	Field	Hospital	Multi-method approach to data collection
1972	Markus	Any facility type	Model for comprehensive building analysis
1974	Becker	Public Housing	Cross-sectional comparative approach to data collection and analysis
1975	Franacescato *et al.,*	Public Housing	Evaluation models of "resident satisfaction" allowing physical managerial intervention
1975	General Services Administration	Office Buildings	Office system performance standards
1975	McLaughlin	Hospitals	"Evaluation of Hospitals" – first published on POE
1976	U.S. Army Corps Of Engineers	Military Facilities	Design Guide Series with updatable, state-of-the-art criteria
1976	Connell & Ostrander	Government	POEs of Postal and Enlisted House
1978	Bechtel and Srivastava	Housing	Comprehensive review of POEs of Housing
1979	Public Works – Canada	Government facilities	POE incorporated into project delivery system
1980	Daish*, et al*	Military facilities	POE
1980 *	Marans	Offices	Evaluation model linking perceptual and objective attributes
1981	Palmer	Any facility type	Programming linked to POE methodology
1982	Parshall/Pena	Any facility type	Simplified and standardized evaluation methodology for practitioners
1983	Duffy & Chandor	Offices	Systems design standards
1984 *	Brill, *et al*	Offices	Linking worker productivity and office design
1986	American Society for Testing and Materials	Any facility type	Performance ratings of existing facilities
1986	Goodrich	Public Square	Observational POE Methodology
1987	Building Research Board	Any facility type	"POE Practices in the Building Process"
1988	Preiser, Rabinowitz & White	Any facility type	"Post-Occupancy Evaluation" – first book on POE Methodology
1989	Farbstein	U.S. Postal Service	POE & organizational development
1989	Preiser	Any facility type	"Building Evaluation" – POE case studies from around the world
1992	Sanoff	Any facility type	Integrating programming, POE and user participation in design
1996	Baird, *et al.,*	Any facility type	"Building Evaluation Techniques" – first comprehensive methods book
1996	Davis & Szigeti	Any facility type	Performance standards
1997 *	Preiser & Schramm	Any facility type	"Building Performance Evaluation" framework
2001	Federal Facilities Council	Any facility type	"Learning From Our Buildings" – Federal POE/BPE overview
2001 *	National Clearinghouse	Educational facilities	Feedback-based design standards for schools
2003	NCARB	Any facility type	"Improving Building Performance" – a study guide for architects
2005	Preiser & Vischer	Any facility type	"Assessing Building Performance" – global BPE book
2007	Nasar, Preiser & Fisher	Any facility type	"Designing for Designers: Lessons Learned from Schools of Architecture"
2009	OECD	Educational Facilities	First coordinated effort of the Organization for Economic Co-operation and Development -

Source: Preiser (2010)

The divisions between Industry and Academia, in particular the “perceived” failure of environmental psychology (Cooper, 2001) has had damaging effects on the application of POE. Reflecting on the lessons learnt from the Probe studies, Bordass and Leaman (2005) suggest one of the reasons why building assessments often have an uncomfortable relationship with the academic world is due to the difference in emphasis – Industry tends to focus on decision-making, risk and consequences, while academia is more concerned with knowledge creation, theory building or indeed hypothesis testing. As a consequence, one of the complications for researchers working in this field has been to understand the difference between consultancy and research, in particular how the latter informs the former.

Dainty *et al.*, (2006) suggest the construction industry’s structure and obligations have meant responsibility ends at practical completion. POE or more specifically ‘aftercare’, is an element of service, which traditionally has not existed. O’Neill and Duvall (2004) also note that because many view POE as a one-off evaluation, its impact will be relatively modest.

Vischer (2001) suggests costs, defending ones professional integrity, and the time and skills required, are all factors, which inhibit POE as a mainstream activity. Doidge (2001) reaffirms this view, suggesting that the greatest obstacle to POE studies is that professionals must guard their reputation and avoid litigation. Lackney (2001) also raises the issue that POE surveys can potentially generate bad publicity, especially where public funds are involved.

Naturally organizations are cautious about issues to do with litigation and commercial accountability. Cooper (2001) has therefore suggested until such questions about “ownership” are resolved i.e. who takes responsibility for carrying out a POE, its development as a construction discipline will remain stunted. Despite these concerns, professionals continue to deflect responsibility away from themselves in the knowledge they are not obliged to carry out further analysis beyond practical completion.

A further obstacle which needs to be addressed considers the question of money – who should pay for a POE? Cooper (2001) suggests clients will be reluctant to pay, whilst Zimmerman and Martin (2001) cite a lack of financial incentive as a reason why architects rarely revisit past projects. Given that both the client and the designer may perceive POE to be costly and ineffective, Bordass and Leaman (2005) suggest processes and methods will need to become cheaper and less time consuming. Standardising a methodology for particular buildings such as schools is an area this research has considered.

The British Council for Offices (2007) documented their findings which are summarized in the table below. Evidently, the overriding concern regarding POE has been the culture of accountability and distrust. Indeed without a culture of collective responsibility, it seems unlikely practitioners will voluntarily evaluate and improve their buildings.

Table 2. Perceived Barriers to POE

Stakeholder	**Perceived Barrier**
Occupiers	*'The designer or facilities manager will benefit most from conducting a POE so why should we pay for the service'.* *'It will cause disruption to staff or raise HR issues'.*
Design Team	*'If the design is found to be poor, the study may have a detrimental effect on our reputation'.* *'We're worried about liability – the evaluation may reveal defects or areas where the brief has not been fully met and we may be held accountable'.* *'The cost of providing a POE service'.*
Facilities Managers	*'It will ''open a can of worms'', and anyway we haven't received any complaints, so we don't need a survey.'* *'The cost of conducting a survey.'*

Source: British Council for Offices (2007)

Looking at the way in which POE has advanced from an academic perspective, Preiser (1988), one of the original contributors to the POE field, has differentiated between three levels of POE research activity,

Level 1: **Indicative** POE provides an indication of major failures and successes of a building's performance. This type of POE is usually carried out within a very short time span, from two or three hours to one or two days. There are four typical data-gathering methods: archival and document evaluation, walk- through evaluation, evaluation questions and selected interviews.

Level 2: **Investigative** POE is more time-consuming; more complicated, and requires many more resources than an indicative POE. Often an investigative POE is conducted when an indicative POE has identified major issues that warrant more detailed study. The evaluation criteria are explicitly stated before the building is evaluated. Spending much more effort and time on the site, the establishment of the evaluation criteria involves at least two types of activities: "state-of-the-art" literature and comparisons with recent, similar "state-of-the-art" facilities.

Level 3: **Diagnostic** POE is a comprehensive and in-depth investigation conducted at a high level of effort. Typically, it follows a multi-method strategy, including questionnaires, surveys, observations, physical measurements and may take several months or years to complete. The results of diagnostic POEs are meant to improve particular facilities and the depth of knowledge in that specific building type. Moreover, the methodology used is similar to the rigour found in traditional "scientific" research.

Further distinctions were made by Bechtel (1997), identifying 5 types of POE.

- **Academic Studies** are mostly carried out by architect students.
- **Scientific Studies** usually involve aspects of environmental psychology based around practice more strongly associated with social science.
- **Collaborative Evaluations** involve social scientists and designers in make a real difference.
- **Institutional Evaluations** usually involve government agencies or large corporations who recognise the importance of "feedback" to improve their products and services.
- **Entrepreneurial Evaluations** involve specialist organizations who carry out POEs for profit.

Other areas where ambiguity resides involves the development of benchmarking methodologies which measure sustainability. Interestingly, Roaf (2005) explains how,

> "*... unless a systematic approach is taken for the benchmarking of buildings, improvements of current practices is left to a haphazard process that does not necessarily promote sustainability" (p.190)*

He then breaks down benchmarking into 3 categories.

1. "**Absolute"** benchmarks: Those which are statistically driven and support national and regional targets.
2. **"Relative"** benchmarks: Where buildings of different sizes can be compared using normalisation techniques which typically divide energy consumption by total floor space.
3. **"Tailored"** benchmarks: Using data (feedback) from a "diagnostic" POE to ascertain detailed performance characteristics of specific buildings.

As discussed previously, to overcome the various "barriers" which prevent the mainstream adoption of POE, Meir *et al.,* (2008) identify the main stakeholders, their motivations, and by extension, the potential conflicts of interest which can arise.

- **The Entrepreneur** is focused on delivering "low cost"-- "best" product.
- **The Building Manager** is focused on reducing energy and maintenance costs.
- **The Building User** is concerned about personal well being, health and productivity.
- **The Architect and Consultant** want to create the best possible building.
- **The Institutional Stakeholders** are focused on delivering "value for money", added longevity and minimizing the need for change.

For the current research, the characterisation of each stakeholder has helped direct the analysis, looking for evidence to either falsify or corroborate these "motivations". Interestingly, BSF's procurement system was designed with the intention to resolve potential conflict and incentivise "shared" interests through the development of the PPP LEP model.

More recently, the emergence of sustainable development as the mainstream response to the challenges presented by climate change has increased the focus on reducing CO_2 emissions in buildings. This in turn has identified POE as an important part in the process of improving design and operational efficiency. According to Meir *et al.,* (2008) 40% to 50% of the developed world's emissions originate from buildings as more and more people spend increasing amounts of time indoors, studying, working, cooking and even exercising (swimming, sports centres, gymnasiums etc). Moreover, as can be seen from the way POE has evolved, identifying the "type" of building, is equally important when seeking to understand how occupancy behaviour influences energy efficiency. Indeed, as Meir *et al.,* (2008) explain,

> "*Perhaps one of the areas in which POE has a most compelling role, and is also most likely to make inroads in institutional terms, is in the design and construction of schools. As opposed to private and corporate construction process, schools are in the public domain and need to balance utility and innovation and, in many districts, must respond to serious public accountability" (p.207)*

To what extent PFI blurs the boundaries of public and private sector accountability remains unclear. However, as Meir *et al.,* (2008) continue,

> "*The UK has put an emphasis on determining better design practices based on POE for educational buildings and community involvement in the design process... A school may be designed in accordance with all the conventional and green criteria but in practice may not lend itself to occupants to use it to its potential. These errors can only be corrected if POE addresses these issues and the results are honestly and openly publicized" (P.207-208)*

However, when the researcher consulted the advisory documentation which Partnership for Schools produced, there was little guidance about post-occupancy evaluations in terms of methodology or purpose. As a result, this literature review has identified a range past POE studies which looked specifically at educational buildings using a range of tools and techniques which may inform the development of a standardised POE methodology which UK Schools can be measured by.

Table 3. POE Studies on Educational Facilities

Reference	Title	Building Type	Dimensions Evaluated	Methodologies	Scope
Baird and Jackson (2004)	Probe-style questionnaire surveys – an international comparison of their application to large-scale mixed mode teaching and research facilities	Academic, educational, office	Users satisfaction, use of space, thermal control	Public access of POE/PROBE surveys	3-5 days, 5 Buildings (complexes) 1241 respondents
CABE (2006)	Assessing secondary school design quality – DQI index	Secondary Schools	Building functionality (access, space and uses), built quality (performance, engineering and construction), and impact (sense of place and effect on community).	Photographic walk through, database evaluations written by design and construction professionals trained as CABE enablers, client interviews, follow-up, web surveys of enablers of overall recommendations	2000-2005, 52 Schools
Donnell-Kay Foundation, Denver CO (2005)	School facility assessments: State of Colorado	School	Assessment of physical condition, educational suitability, technology readiness, site condition and capacity/utilization	BASIS® School facility assessment system	2004, 7 Colorado districts, 22 Schools
Etzion *et al* (1993)	Project monitoring in the Negev and the Arava, Israel	Residential, office, educational	Indoor temperatures, thermal performance	Monitoring	Student accommodation, 1 multifunctional educational building
Frenkel *et al* (2006)	POE of scientists' village complex in the desert – towards a comprehensive methodology	Educational complex	Energy consumption, IEQ	Short-timing monitoring, observations, questionnaire surveys	Educational complex: office building, dorms, classrooms, facilities
Langstone *et al* (2008)	Perceived conditions of workers in different organizational settings	Educational, office, commercial	User satisfaction, use of workspace in addition to thermal, visual, acoustic comfort	Questionnaires	2 years, 14 case studies, 555-4500 respondents
Lighthall *et al* (2006) **	Renovation impact on student success	School	Impact of large scale renovations of school buildings on facilities, student achievement, attendance and suspension rates, as well as the impact of stakeholder satisfaction	Data were collected and analysed from end-of-grade and end-of-course exams, the impact on stakeholder satisfaction, SAT scores, average daily attendance, out-of-school suspensions and parent satisfaction surveys. Interviews were also conducted with school staff regarding their satisfaction during and following renovations	2005, 18 Schools
Loftness *et al* (2006)	Sustainability and health are integrals goals for the built environment	Offices, Schools, Hospitals	User satisfaction, worker productivity as function of all aspects of health and well being in built environment, SBS, energy consumption conservation, VOC, TVOC, visual comfort, thermal comfort, ventilation, pathogens, allergens	Review of published research, correlation of results	1995 - 2005
Meir and Hare (2004)	Where did we go wrong? POE of some bioclimatic projects, Israel	Schools, visitor centre, residential, landscape	Occupancy control of systems and windows, maintenance, training of occupants	Walk-through, interviews	Single Buildings

Pitts and Douvlou-Beggiora (2004) **	Post-occupancy analysis of comfort in glazed atrium spaces	Educational Building	Thermal Comfort	Measurements	Summer and winter, 300 respondents
Sanoff (2004)	Schools designed with community participation	Schools	User satisfaction	Walk-through and surveys by clients (teachers) POE in conjunction with design process	2000, 50 teachers participated
Watson (2003)	Review of building quality using post-occupancy evaluation	School, dormitory	User satisfaction	Walk-through and surveys by POE interviewers	3 projects
Watson (2005)	Post-occupancy evaluation – Braes high school, Falkirk	School	User satisfaction	Walk-through and surveys by clients. Pupils, staff and school users, as well as council officials and technical staff involved in the design construction and maintenance of the building.	2000, 55 stakeholders incl.

Source: Meir *et al.,* (2009)

2.2 Knowledge Management: From POE to BPE

From an academic perspective, Professor Wolfgang Preiser, an academic within the field of architecture, developed the Building Performance Evaluation (BPE) Framework – a knowledge management system.

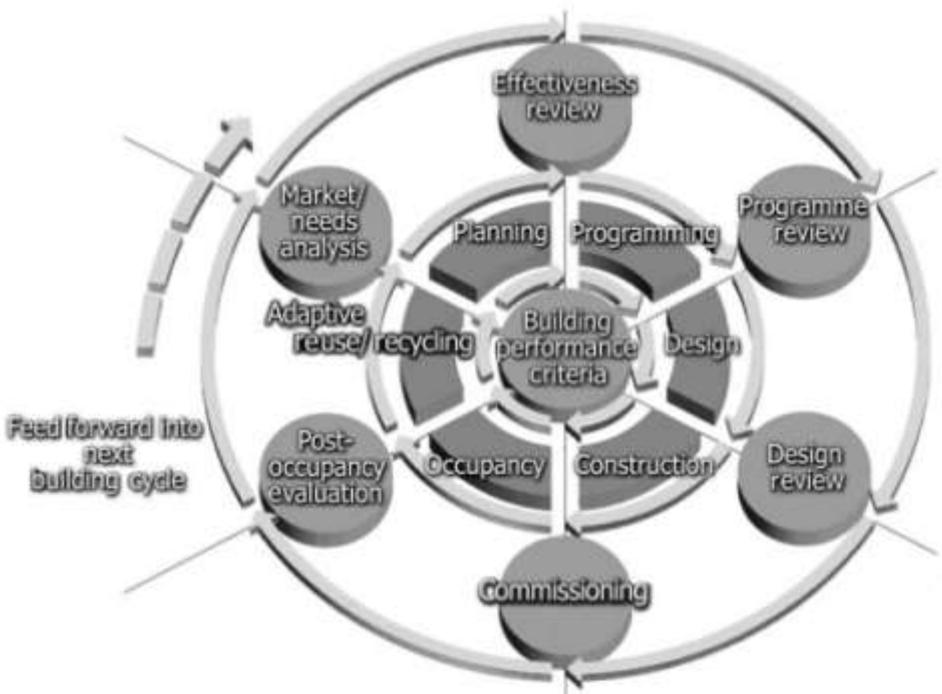


Figure 2. BPE Framework

According to Preiser and Vischer (2005),

> "*BPE came into being as a result of knowledge accumulated from years of post-occupancy studies of buildings, the results of which contained important information for architects, builders and others involved in the process of creating" (p.3)*

His research has also helped to identify three basic levels of functionality which a building must address.

Level 1: Health, Safety and Security Performance,
Level 2: Function, efficiency and work flow performance,
Level 3: Psychological, social, cultural and aesthetic performance

A more thorough description of BPE's purpose and development has been summarised by Presier *et al., (*2012), shedding light on areas of the construction industry which may also help to influence the direction of the present research as different aspects of the BSF programme are examined.

> "*Building Performance Evaluation is a systematic and rigorous approach encompassing a number of activities including research, measurement, comparison, evaluation, and feedback that take place through every phase of a building's lifecycle: planning, briefing/programming, design, construction, occupancy and recycling. BPE focuses on the relationship between design and technical performance of buildings in relation to human behaviour, needs and desires. That is, BPE determines whether facilities will work for the people that will use, occupy, or otherwise be impacted by them. Evaluations can be used to identify and correct problems in individual buildings and the lessons derived from the successes and failures of many building studies can be used to inform the planning, programming, design and management of future buildings. Learning from the past and feeding forward knowledge helps to avoid repeating costly mistakes. The goal of integrating evaluative processes into the design and management of built environments is, therefore, to support better decision-making and ultimately enhance building performance... " (p.3, 'Enhancing Building Performance, 2012)*

2.3 Project Management: The Soft Landings (SL) Framework

More recently, experts from the UK have developed more practical "project management" systems to support the design process from start to finish. In 2003 Mark Way, in conjunction with a wide range of UK construction companies developed the Soft Landings Framework for similar reasons to those expressed by Preiser when developing the BPE framework. Quoting verbatim from the foreword at the beginning of the 2007 SL report,

> "*As an industry, we have often seemed incapable of learning about the performance of our own creations, with the inevitable result that buildings regularly fail to meet our owners' operation expectations or, worse are demolished less than a generation after their completion. For those outside the industry the idea of continual improvement – ploughing back the lessons from one completed project to the next – must be obvious, but, with few exceptions, this is rarely done by an industry too obsessed by capital cost. Shortcomings in basic requirements such as comfort, energy consumption and adaptability are not only irritating but costly in their own right, but also undermine attempts to achieve high levels of sustainability... There are reasons for optimism. The need for lower-carbon buildings is rapidly establishing a culture for measurement of energy that is a stone's throw from greater knowledge about performance in general. Systematic, post-occupancy evaluation is widely recognised to be a hugely important step in the right direction, but it needs to be linked to rational methodology for assessing briefing, design and commissioning stages. This is where Soft Landings comes into its own, closing the loop between design, construction, operation feedback and into design again..."*

Designed to work alongside RIBA's "Plan of Work" framework (see Appendix A), Soft Landings has also been adopted by a number of contractors working on the BSF programme. In recent reports, feedback from practitioners has been collected at each stage in the process.

Stage 1: Inception and Briefing,
Stage 2: Managing expectations during design and construction,
Stage 3: Preparation for Handover,
Stage 4: Initial After Care,
Stage 5: Longer term aftercare and post-occupancy evaluation.

Stage 1: Inception and Briefing

Stage	Project	Initiator and Status	Activity	Outcome
1	Joseph Leckie School Wallsall.	Willmott Dixon. Occupied in June 2009	Review of lessons learned and the appropriateness of SLs for future activities	Opportunities identified for SLs to shape future work
1	South Tyneside and Gateshead (StaG) school building and refurbishment LEP programme	Ryder Architecture. Major ongoing programme	Review of the SLs activities already included within the programme, and whether more can be done	Plans to do more, but some concern about extended aftercare period
1	Incorporating findings from post-occupancy evaluation in new school projects	Buro Happold. Continuous improvement in design	Using understanding of performance in use to influence priorities in engineering design and teamwork	Preference for simpler technical solutions to avoid unmanageable complication. Need to tackle unoccupied loads and ICT.

NB. *The information contained within these sections have been paraphrased and summarised from the 2010 Soft Landings Case-Study report which looked at newly constructed schools.*[2]

The initial findings identified how Soft Landings needs to be implemented from the very start of the project in order to be successful. There needs to be high levels of support from school governors so that decisions are taken quickly. And finally, conflicts between ICT and Facilities Management were highlighted due to a lack of clarity regarding contractual responsibility.

Stage 2: Managing Expectations during design and construction

Stage	Project	Initiator and Status	Activity	Outcome
2	Southwark Schools PFI programme	Buro Happold. Major ongoing programme	Proper definition and management of energy and carbon performance to meet 27kg of CO2/m2 target	More effective procedures including early involvement of ICT and catering
2	Sustainability review process	Feilden Clegg Bradley and Max Fordham	An approach which allows design targets to be established and kept under review	Adopted on a number of projects by these two firms

This phase of construction produced some important discoveries. The BSF procurement system was criticized for interrupting dialogue between designers and users. As a result, fragmentation of tasks and responsibilities made project management more difficult. That being the case, practitioners did report how the Soft Landings Framework can help to support better communications across the range of practitioners working on site.

[2] https://www.bsria.co.uk/information-membership/bookshop/publication/soft-landings-for-schools-case-studies/

Stage 3: Preparation for Handover

Stage	Project	Initiator and Status	Activity	Outcome
3	Hackney City Academy	Max Fordham. Handed over in summer 2009	Improved pre- and post-handover processes, SLs Stages 3 and 4	SLs principles partly implemented, but too late for major impact
3	Estover, Plymouth	Feilden Clegg Bradley Studios with Kier	Managing a phased handover process with a design-and-build contractor	SLs has informed the process, with design and specification changes
3	RSA Academy, Tipton Sandwell	Davis Langdon. Handover in summer 2010	Review of progress in relation to SLs and lessons for the future	SLs approach would have helped and will assist Stages 3 and 4
3	A new secondary school and a primary school to be refurbished in phases	Buro Happold. New School handover in 2010	Retrofit of SLs, with concentration on handover processes.	It proved too difficult to retrofit SLs into existing arrangements.

This stage of the construction process relates to the “commissioning” activities which ensure the building is ready for occupation. Feedback from practitioners identifies how the Soft Landings framework was particularly useful in complicated buildings where the integration of services can be more complicated. In addition, they also highlight the importance of supporting schools through “awareness training” which the Facilities Management company should provide.

Stage 4: Initial aftercare

Stage	Project	Initiator and Status	Activity	Outcome
4	Hackney City Academy	Max Fordham, initial year	Raising Awareness courses for staff and students.	Starting, six months later than anticipated
4	City Academy	BSRIA. Handed over in 2008	Attempt to retrofit the initial aftercare period to improve performance. Some problems resolved, but some difficulties in obtaining support	Reinforces the need to adopt SLs at an early stage supported by contractor, FM provider and School Governors.

Moving beyond the time when the schools were first occupied, practitioners identified how extending the handover period would allow more time for staff to settle into the new building. Disappointingly, there were numerous occasions when the facilities management provider was criticized for delivering sub-standard levels of “customer support”.

Stage 5: Longer term "Aftercare" and "Post-occupancy Evaluation"

Stage	Project	Initiator and Status	Activity	Outcome
5	Performance review of a "green" primary school	BSRIA. School in operation for five years	Predominantly a survey of energy use in operation.	Sources of wastage identified, with wider implications
5	Long term energy performance of City Academies	Buro Happold. Schools in use for 4 to 6 years	Revisits to City Academies that had been reviewed in 2005-2007 and some others	Opportunities to reduce electricity use especially from ICT
5	Routine adoption of Post-occupancy evaluation processes for all school projects	Feilden Clegg Bradley and Ann Bodkin. In fourth year of operation	A new method has been developed and tested at Northampton Academy. It focuses on students, items of architectural interest and CABE's ten points	The method has proved successful and complements existing techniques.

As more data became available about the operational performance of the buildings, POE was recognised as a useful activity, helping practitioners understand how their architectural designs played out in reality. This involved benchmarking buildings for fairer comparisons with energy efficiency targets. Occupancy satisfaction surveys were also identified as a helpful tool when linking the design to the educational requirement. In one particular school, annual electricity consumption was halved when improvements were made to the building's control settings. More generally, POE has the potential to support existing buildings as well as improve design solutions for the future. In this regard, POE can be seen as a tool which generates new knowledge so that complex multi-purpose buildings can become more efficient, more comfortable, and ultimately more "sustainable".

2.4 What is Commissioning?

The term commissioning originates from shipbuilding and focuses on two areas; the installation and testing of equipment, and the training of crew. In construction, various types of commissioning have been defined by Holtz (2010).

- **Commissioning** => process applied to new construction and major building renovation projects.
- **Retro-commissioning** => performed on facilities that have been in service and were never previously commissioned.
- **Re-commissioning** => facilities previously commissioned and in need of a 'tune-up'.
- **Continuous commissioning** => ongoing programme of structured commissioning throughout the lifetime of a building.

Looking briefly at the role commissioning plays in the creation of a new building, a number of additional phases have also been identified (Holtz, 2010).

Design Phase Commissioning: The intent is to review the proposed design from an operations, maintenance and performance perspective, and to identify and resolve issues 'on paper' before they become actual physical (construction) or operation problems 'in the field'.

Construction Phase Commissioning: Interaction between the commissioning agent and the construction team, which usually comprises the general contractor and the subcontractors.

Acceptance Phase Commissioning: Functional performance tests verify the intended operation of system components and associated controls under various conditions and modes of operation, although the building is still at this point unoccupied.

Warranty Phase Commissioning: Involves the short-term diagnostic monitoring of the building systems under normal occupancy and operating conditions. Short term monitoring is typically performed several times during the warranty phase to address seasonal operation variations. In the best of situations, the warranty phase gives way to a continuous commissioning phase where the building systems are constantly monitored and evaluated, so that their operation and maintenance ensures energy savings and operational reliability.

Holtz (2010) concludes by summarising commissioning as follows,

> "*It is a way of ensuring quality control and protecting the ultimate user or occupant from unsafe or unsanitary conditions, both at the moment of occupancy and over the lifetime of the building. As the complexity and integration of building systems increases, building commissioning will become an essential activity within the building delivery process" (p.70)*

Now that commissioning has been functionally defined, its capacity to address energy costs and carbon emissions was explored at length in a report by Mills (2009).

In his report titled, '*Building Commissioning: A Golden Opportunity for Reducing Energy costs and Greenhouse Gas Emissions',* 643 commercial buildings in America were examined and over 10,000 energy related problems identified. In the literature review, table 4 is presented which identifies the most typical faults which occur in commercial buildings.

Table 4. Faults causing energy efficiencies in commercial buildings

	National Energy Waste (Quads, primary/year)	Electricity equivalent (BkWh/year)	Cost ($billion/year)
Duct leakage	0.3	28.6	2.9
HVAC left on when space unoccupied	0.2	19.0	1.9
Lights left on when space unoccupied	0.18	17.1	1.7
Airflow not balanced	0.07	6.7	0.7
Improper refrigerant charge	0.07	6.7	0.7
Dampers not working properly	0.055	5.2	0.5
Insufficient evaporator airflow	0.035	3.3	0.3
Improper controls setup / commissioning	0.023	2.2	0.2
Control component failure or degradation	0.023	2.2	0.2
Software programming errors	0.012	1.1	0.1
Improper controls hardware installation	0.01	1.0	0.1
Air-cooled condenser fouling	0.008	0.8	0.1
Valve leakage	0.007	0.7	0.1
Total (central estimate)	1.0	94.6	9.6
Total (range)	0.34-1.8	32.4-171.4	3.3-17.3

Adapted from Roth et al. (2005) assuming 10,500 BTU/kWh, and $0.10/kWh

To reinforce the economic impact which this table draws attention to, “Duct Leakage” alone was estimated to cost 2.8 billion dollars ($) per year in electricity wastage. In addition, the report considers the non-energy related benefits which commissioning also addresses.

> “*Commissioning also improves worker comfort, mitigates indoor air quality problems, increases the competence of in-house staff, plus a host of other non-energy benefits” (p.2)*

More recently, they discovered that projects with a comprehensive approach to commissioning attained nearly twice the overall level of savings and five times the savings of the least-thorough projects. They also confirm how smaller buildings, contrary to popular belief, are just as prone to the same degree of energy wastage. Moreover, they conclude by explaining,

> *“... thanks to energy savings valued more than the cost of the commissioning process, associated reductions in greenhouse gas emissions come at “negative cost”. In fact, the median cost of conserved carbon is negative, -$110 per tonne for existing buildings and -$25 for new construction.” (p.1)*

To put these figures in perspective, Mills (2009) takes the view that,

> *“... commissioning is arguably the single-most cost-effective strategy for reducing energy, costs and greenhouse gas emissions in buildings today... applying our median whole-building energy-savings value (i.e. not best practices) to the stock of U.S. non-residential buildings corresponds to annual greenhouse gas emissions of about 340 megatons of* CO_2 *each year” (p.2)*

Furthermore, the economic benefits in terms of job creation identified that the current workforce of approximately 1,500 would have to rise to around 25,000 workers. Given the potential for commissioning to benefit the built environment in the US, it is also important to note how UK schools emit around 3 million tonnes of CO_2 per year (DCSF, 2010). Indeed, with little or no investment in the educational infrastructure, many old and dilapidated schools in the UK will be wasting substantial amounts of energy year on year.

This commissioning report also gathered "qualitative" data about the reasons for instructing commissioning agents based on a large sample of 178 refurbishment projects and 36 new builds. Indeed, whilst energy was a major driver in 90% of the cases, problems associated with thermal comfort, productivity and indoor air quality were also cited. Interestingly, out of the 36 new build projects, factors of greatest importance included (1) general equipment performance (2) indoor air quality (3) staff productivity and finally (4) energy efficiency.

Mills (2009) also highlights how more research is required which looks specifically at the way buildings deteriorate over time when he notes,

> "*The literature on the subject remains sparse, and the periods over which persistence has been tracked are mostly under five years." (p.46)*

Indeed, using the extensive body of data collected for his particular report, when the persistence of building performance was assessed over consecutive years, while some projects exhibited an erosion of savings over time, many did not. In actual fact, the study identifies instances when improvements in performance occurred, prompting the following comments,

> "*This perhaps counterintuitive outcome may be explained by the fact that comprehensive commissioning includes training, and in some cases, installation of permanent metering and feedback systems" (p.46)*

Putting in place a national system or database which continually monitors the performance of BSF schools for example, may help to quantify the potential savings which can be made from "comprehensive" commissioning alone. Furthermore, with Mills (2009) identifying how commissioning existing buildings tends to produce the greatest savings, whilst new builds are vastly superior in terms of thermal efficiency, a national policy to promote 'retro' commissioning may need to be considered to address the inefficiencies throughout the existing estate of schools.

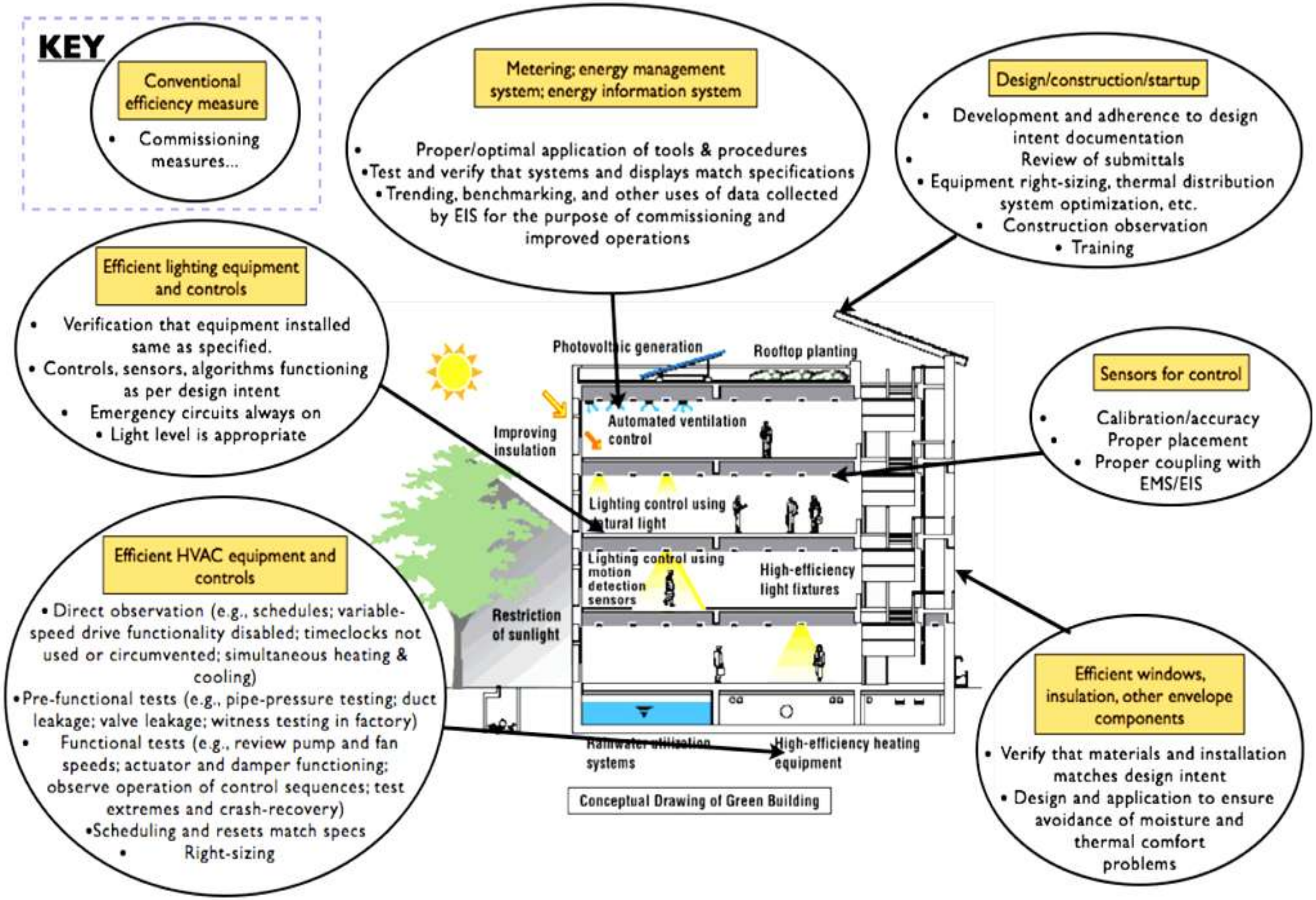


Figure 3. Monitoring Based Commissioning (Mills, 2009)

2.5 UK Energy Consumption and Buildings

This section looks at energy consumption in the built environment. The topics to be discussed include,

- Energy consumption and Trends
- Benchmarking methodologies
- Demand profiles
- Energy saving measures

Energy consumption in the UK has increased from 2,326TWh in 1985 to 2,850TWh in 2001 based on figures published by the department for Business and Enterprise and Regulation reform (2008), which equates to an increase of 22.5%.

At what point demand exceeds supply will depend on a range of factors. In this report, energy efficiency in school buildings has become the focus of attention. From a global perspective, Perez-Lombard *et al.,* (2008) highlights the following points underlining the scale of savings required to stabilise carbon emissions.

1. In 1970 developed nations consumed 37,216TWh, by 2005; this had increased by 72% rising to 63,965 kWh.
2. By 2025, they predict that consumption across developed nations will rise to 80,000TWh.
3. In contrast, developing nations in 1970 only consumed around 10,000 TWh per year.
4. By 2025, they predict that consumption across the developing nations will rise to around 90,000TWh.

NB. Globally, energy consumption has risen by approximately 360% in half a century! The construction sector should look to make a sizable reduction in this regard.

According to Kelly (2006), over the past decade, energy consumption has risen on average by 1% per annum, with electricity demand rising by 2% p.a. Moreover, with the majority of energy derived from the combustion of fossil fuels, the question remains – is our increasing demand for energy “sustainable”?

In 1970 the UK's total consumption was 180TWh. However by 2001 this had increased by 25% to approximately 230TWh. Kelly (2006) also notes how the UK's economy has significantly changed over the past 40 years, with heavy industry declining by around 44% whilst the services sector increased by 66% (up to 2005). During this same period, the domestic sector increased by 122% from 90TWh in 1970 to 200TWh in 2005.

As a result, various academic commentators (Mortimer *et al.,* 1998; Dimoudi *et al.,* 2009) have attempted to understand the factors which shape societal attitudes and behaviour patterns. More recently, with the price of conventional utilities such as petrol, gas, and electricity continuing to rise above the level of inflation, energy efficiency has now become an important political debate. To what extent a new generation of low-energy sustainable schools can both reduce energy through technological advancements and behaviour change remains to be seen. However, with Display Energy Certificates (DEC) becoming a compulsory feature of large public sector buildings, the ability to measure and benchmark schools based on total floor area (m²) is becoming increasingly important.

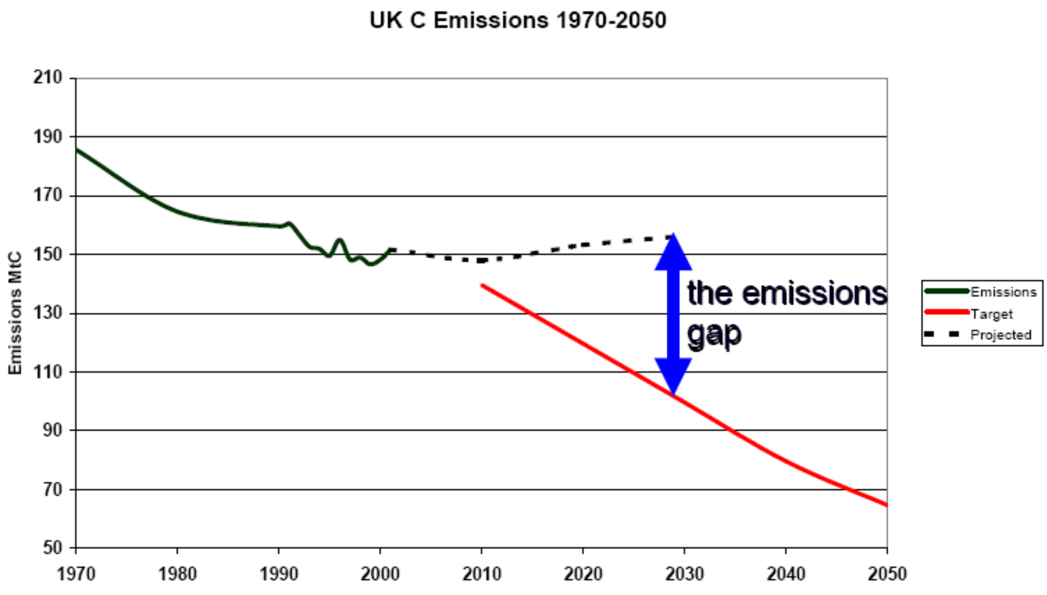


Figure 4. Carbon Reduction Target (Kelly, 2006)

Figure 4 serves to highlight the challenge presented by the government's 80% carbon reduction target by 2050. This position is supported by the historic analysis presented by Kelly (2006) who describes how the gradual reduction in carbon emissions since 1970 was in part explained by the closure of the coal-fired power stations which were replaced with Nuclear Power and North Sea Gas. Indeed, with the UK failing to achieve the 12.5% carbon reductions set out by the Kyoto Protocol and with the population predicted to rise, achieving this 80% target seems increasingly unlikely. Interestingly, the extent to which shale gas can be extracted and exploited may help to stabilise costs temporarily, but as a fossil fuel, carbon emissions are likely to go on rising.

From a European perspective, the Energy Performance in Buildings Directive requires all commercial buildings to display a DEC certificate. However, as Hernandez *et al.,* (2008) point out, many countries have yet to acquire the expertise and resources to collect the required data. Improving efficiency is therefore dependent on the extraction and monitoring of energy data. Moreover, data which is of a "high" temporal range i.e. recorded every 5/10/30/60 minutes etc, enables more detailed analysis to be carried out.

Looking now at the typical energy profile of a UK office based on figures published by the Carbon Trust (2003), the pie chart (figure 5) shows how each "service" uses a certain amount of energy.

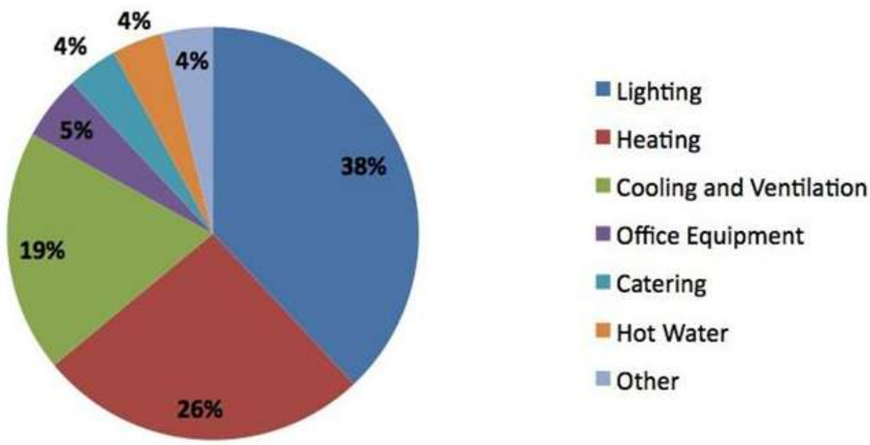


Figure 5. Office Energy Demand (Carbon Trust, 2003)

Looking at where energy is consumed is important to understanding where in the system the "end user" may influence consumption and where the actual equipment needs to be improved. In the above example, we can see how air-conditioning massively contributes to the overall energy demand. It is therefore important that new buildings consider natural ventilation as a viable alternative.

Problems occur however when some aspects of consumption are not clearly defined. This can make comparisons between studies more difficult. Steemers (2003) for example breaks down energy consumption into heating, lighting, refrigeration and fans/pumps but does not consider the non-regulated electrical appliances such as computers and photocopiers. Decisions about accounting methodologies can therefore be problematic. Indeed, as the feedback from the Soft Landings case studies reveal, early consideration about the integration of ICT in new schools can have important implications for HVAC designs as well energy consumption.

2.5.1 Reducing Energy in Schools

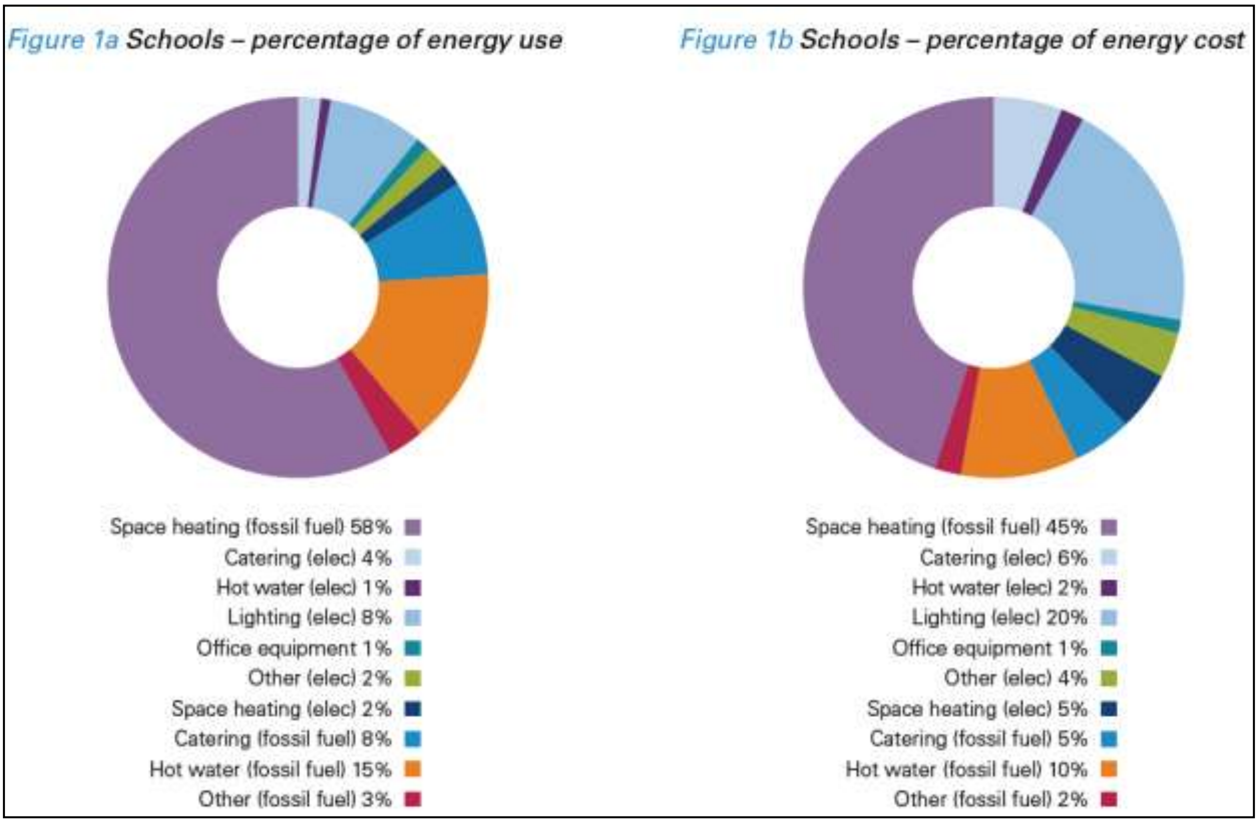


Figure 6. School Energy Breakdown, (Carbon Trust, 2012)

Figure 6 highlights the pattern of consumption across the existing estate of schools. Consequently, the largest consumer of energy is heating (58%). Typically, Gas or Oil may be the main source of fuel used to provide heating. The second largest service to be provided is hot water (15%) which again uses gas as the main source of fuel.

By comparing the two graphics however, we see how the services which rely on electricity are more expensive. Dasgupta *et al., (*2012) summarize the current situation as follows,

> "*Nationally, schools alone are responsible for 15% of the total energy consumption in public and commercial buildings. Locally, schools in England contribute to around 50% of a Local Authority's carbon emissions and as such form a substantial part of the LA's carbon tax and energy payment... There are approximately 25,000 maintained schools in England and Wales with a total school area of 60,000,000m² and a replacement value of £130 billion. In addition to £1.5 billion annual spend on maintenance of schools, the annual cost of energy in 2006-2007 exceeded £420 million... UK schools house nearly ten million pupils who spend almost 30% of their life in schools and about 70% of their time inside a classroom on school days..." (p.6)*

Other studies (Pegg *et al.,* 2007) identify how carbon emissions in newly built schools were substantially higher post-occupancy than was predicted. Dasgupta *et al.,* (2012) also highlight how existing UK benchmarks are mostly unsuitable for new build projects, consisting mainly of Victorian and 1950s buildings. Indeed the Department for Education and Skills (DfES, 2004) identify how the average UK secondary school will consume 155kWh/m² for space heating and hot water, and 39 kWh/m² for services which require electricity with the average school producing 53 kilograms of carbon dioxide per metre square ($KgCO_2/m^2$). Dasgupta *et al.,* (2012) further confirm how,

> "*As of December 2010, based on available data for 43 school buildings, the actual energy use in a newly built school is approximately 2.4 times higher than the designed value, and on aggregate schools emitted approximately 20% more carbon emission than suggested by CIBSE TM 46" (p.7)*

More recently, the Carbon Management Strategy for schools calculates that on present trends, energy savings of 54% will need to be made across the entire stock of schools in the UK (3,500 secondary plus 180,000 primary) in order to meet the 80% reduction target by 2050 (based on 1990 levels) as set out in the 2008 Climate Change Act.

To further underline why design simulations regularly under-estimate the operational design performance of buildings post-occupancy, Dasgputa *et al.,* (2012) point out,

> "*It is to be noted that the compliance methodology does not include non-regulated energy loads [E.g. ICT]. Such a process can lead to significant underestimation of the future building energy consumption if it is assumed that the compliance model predicts total energy consumption..." (p.9).*

Furthermore, complications arise when,

> "*... contractual process and financial limitations lead to the model being run only twice during the design process – once at contractual close (RIBA Stage D – see appendix) and second prior to handover. On the first occasion much of the required information such as ICT loads may not be known. On the second occasion the design process may be too advanced for major changes to be incorporated" (p.10)*

In summary the process of managing such projects is fraught with difficulties, especially when the regulatory and contractual requirements are constantly evolving. As a result, until such time as operational targets for energy efficiency carry fines and penalties for non-compliance, more pressing concerns to do with costs and planning consent will take precedence. Indeed, Dasgupta *et al.,* (2012) identifies the following "barriers" which obstruct the capacity to deliver low-carbon buildings,

1. A lack of funding.
2. A lack of time.
3. Design decisions based, not on life cycle costs, but on capital investment.
4. Decision makers in the design phase, including Local Authorities and the main contractor, do not benefit from long term utility savings i.e. there are no long term financial incentives.

5. Energy standards[3] and definitions for “zero carbon” schools are inadequate because;
    a. Off-site energy generation or large scale district heating systems are excluded.
    b. Operational targets (kWh/m²) are not part of the regulatory or contractual setup.
6. Predictive energy simulations do not take account of unregulated loads such as ICT and extended “community” use.

2.5.2 Energy Benchmarks

With little data available about the energy performance of newly built secondary schools in the UK, the BSF programme did not have a clear framework through which to judge the performance of schools post-occupancy. The Carbon Trust (2003) has provided models of offices which they separate into four categories, 1. Naturally ventilated, 2. Naturally ventilated open plan, 3. Air conditioned (standard), and 4. Air conditioned (prestige). With these four categories in mind, performance targets were defined either as “typical” or “good practice”.

At this present time, benchmarks for UK schools have yet to be developed which provide sufficient detail and guidance. Distinguishing between primary and secondary schools would be the first sensible division. Further sub-groups may wish to consider the age of the building, the number of pupils, the total floor space, and any other information which may be relevant such as the inclusion of a Gymnasium or Swimming Pool.

This additional information can then be used to ‘normalise’ the data so that buildings of similar size and capacity can then be compared. Chung *et al.,* (2006) in their paper, *‘Benchmarking the energy efficiency of commercial buildings’* identify a number of techniques for benchmarking energy performance. Typically, a building’s heated floor (m²) area and annual consumption (p.a) are used (kWh/m²/pa). To further customize this normalisation process, additional data specific to schools could be used e.g. pupils numbers.

In some cases, statistical techniques are used to assess the efficiency of a heating system as seen with degree day analysis using the statistical method of linear regression. Examining this relationship may help to identify instances where efficiency savings can be made. Reducing a

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[3] BREEAM compliance only looks at “design quality” for BSF schools.

building's internal set point temperature from 21°C to 20°C may for example help to alleviate overheating and reduce energy consumption at the same time.

Chung *et al.,* (2006) were also interested in the behaviour patterns of building users, identifying the following 6 questions,

1. Occupants turn off lights when not in use? Y/N
2. Occupants turn off Air Conditioning when not in use? Y/N
3. Occupants turn off 'other' equipment when not in use? Y/N
4. Occupants set energy targets? Y/N
5. Independent Energy Audit? Y/N
6. Is regular maintenance/re-commissioning carried out? Y/N

Looking across the literature for evidence of secondary school energy performance, the bar chart below compares three sources of operational energy benchmark data.

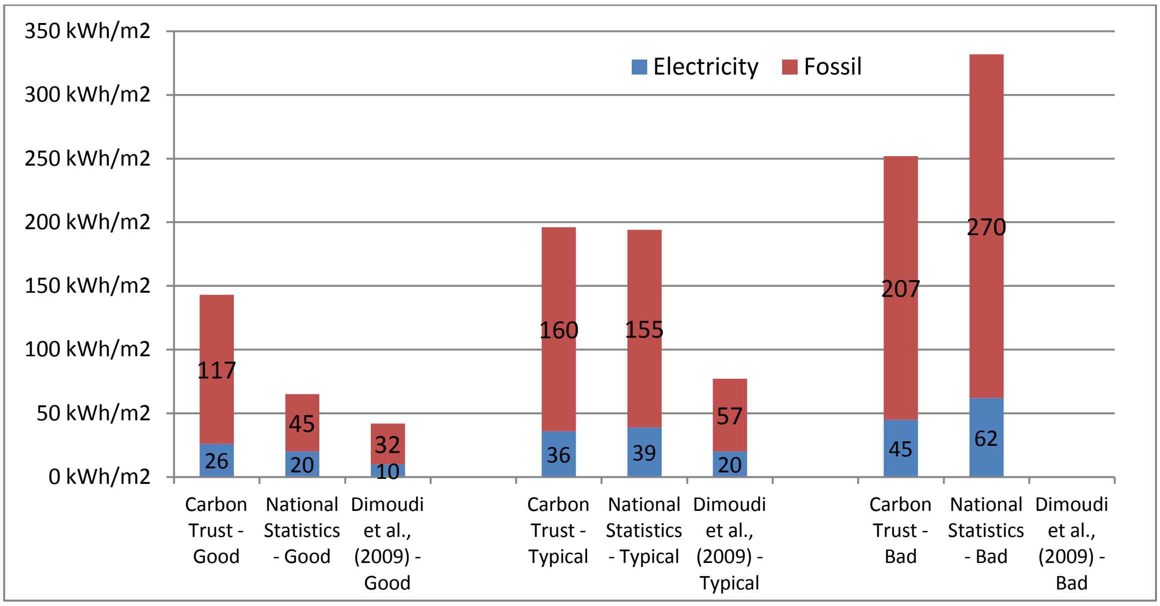

Figure 7. Benchmark Comparisons of Secondary Schools (Kilpatrick, 2011)

What is helpful about this benchmark data is the way data has been separated into 3 groups – Good, Typical and Bad. However, the variation within these groups highlights the need for a more centralised monitoring system as recommended by the James Review (2011). The proportion of (heating related) fossil fuel (80%) and electricity consumption (20%) suggest however these benchmarks derive from older buildings. In new schools this trend tends to reverse, as more and more electricity is required for lighting, air-conditioning and ICT use. At the same time, minimum standards for building materials have improved the thermal efficiency of modern buildings, substantially reducing the consumption of gas, oil or electricity required for space-heating.

2.5.3 Data Analysis Techniques

To understand what factors ultimately drive energy consumption it is important to consider what available data exists for each building. Lam *et al.,* (2008) for example looked at the way energy was consumed in buildings across China. Local climate and seasonal variation were seen to be the main causal factors driving their analysis. They suggest that 65% of energy consumption in the built environment can be attributed to the HVAC systems. Making sure the Building Management systems (BMS) are correctly programmed to adjust according to different weather patterns and occupancy usage will be important in helping to improve overall efficiency. In order to identify instances where inefficiencies may be occurring ('sharp peak', fig.8), analysis of high resolution data is required so that "daily power" profiles can be generated.

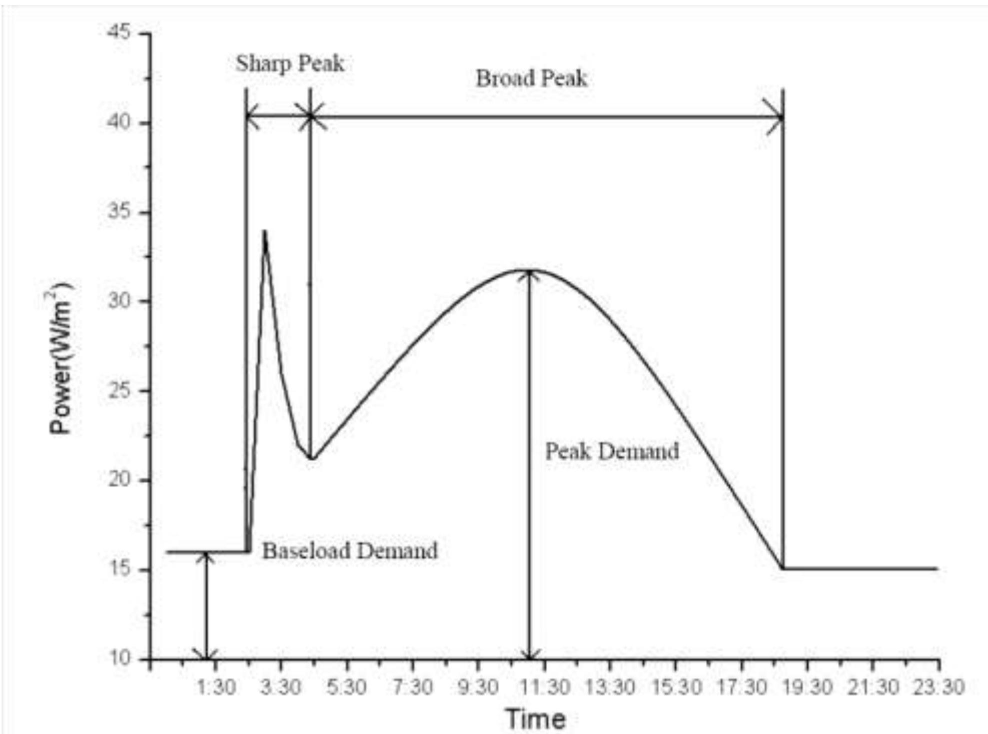

Figure 8. Daily (24h) Power Profile (Kilpatrick, 2011)

Whilst figure 8 is indicative of a building's daily 24 hour electricity demand, this same technique can easily be applied to other utilities assuming consumption monitoring is recorded at regular intervals throughout the day (Wright *et al.,* 2007). More recently, utility companies have begun to collect "power" readings (kW) every 30 minutes for large non-domestic buildings, referred to as "half hourly" data. In domestic dwellings such as houses and apartments this interval is often smaller (every 5 minutes) to reflect the more specific habits of the individual customer.

Zakaria *et al.,* (2002) explore how utility companies make use of profiling their customers using high resolution data so they can develop new services and tariffs based on a more detailed understanding of energy usage. Indeed, whilst they concede that collecting data for each and every customer on a minute by minute interval is both impractical and expensive, a range of customer profiles have been developed in order to suit particular lifestyle preferences. In the UK "economy 7" for example allows customers to use electricity more cheaply at night time. Further refinements of this kind may help to manage demand across the grid if particular activities can be scheduled outside of working hours Monday to Friday, 9am to 5pm.

Looking at the way different seasons influence electricity and gas consumption, Wright *et al.,* (2007) show two graphs of the same building in winter and summer. Interestingly, the electricity profile for summer (red line) is greater than winter (black line), suggesting that "Phoenix House" is an air-conditioned building. It can also be seen how on Saturday (far right), electricity demand drops by more than 50%, and Sunday (far left) the building is not in use at all.

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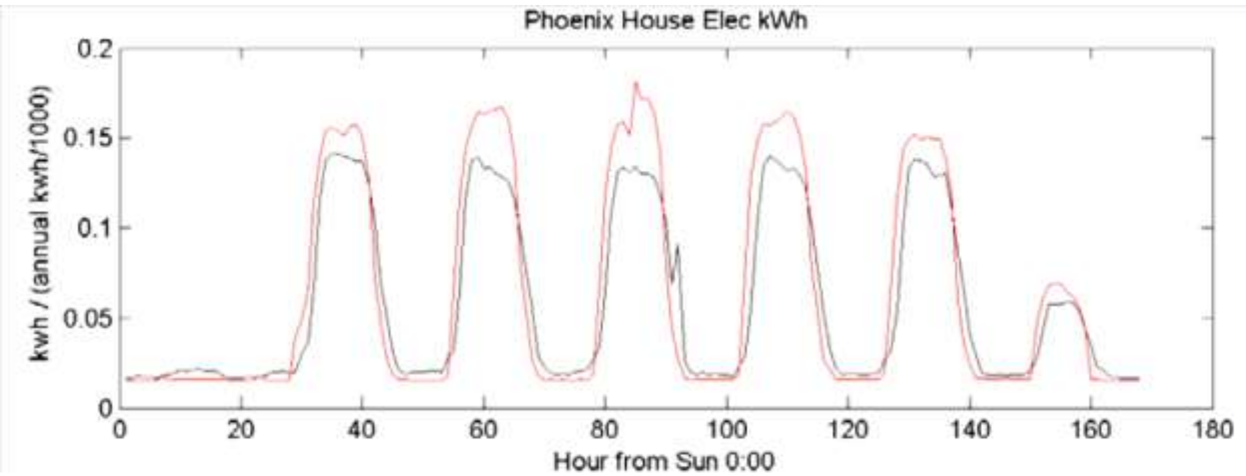

Figure 9. Seasonal Electricity Profiles (Wright *et al.,* 2007)

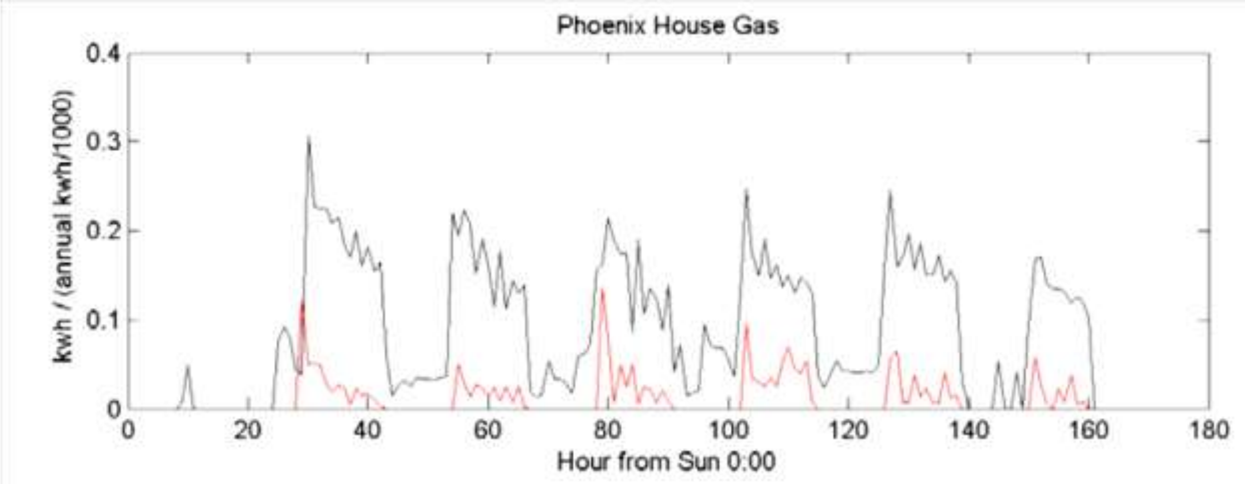

Figure 10. Seasonal Gas Profiles (Wright *et al.,* 2007)

In contrast, figure 9 illustrates how the same building consumes substantially more gas in winter compared with summer as the black and the red lines indicate (respectively). Wright *et al.,* (2007) in their examination of 149 buildings identify four typical problems most likely to occur,

1. Heating/Cooling timer settings out of sync with seasonal weather patterns,
2. Unoccupied heating/cooling systems remain on,
3. Stand-by/base-load issues (services remain on out of hours – heating lighting pumps etc),
4. Excessive consumption (equipment malfunctions).

2.5.4 Energy Efficiency

From an end-user perspective, the Carbon Trust has published various guidance reports, detailing how schools can improve their energy efficiency. Most of the recommendations are intended for existing schools where the infrastructure is old. To reduce the demand for space heating, improvements to a building's external envelope such as the walls, windows or roof have been suggested. Likewise, regular servicing of the boiler system, checking local radiator thermostats and insulating pipe-work can also improve a heating system's operational efficiency. More expensive upgrades mentioned include, replacing the boiler and control system. Indeed, as mentioned earlier, the savings from upgrading and re-commissioning the existing stock of schools are considerable both in terms of costs and emissions.

Upgrading lighting systems can also improve the aesthetic quality of the environment which may also attract further efficiency savings. The Carbon Trust also advises that a proactive approach which encourages staff and students to switch off lights and ICT will make an important contribution.

At the same time, technology advancements such as occupancy sensors can help reduce electricity consumption. Similarly, computers which utilise power management software can be linked to the building's BMS controls. Indeed, the Carbon Trust (2008) estimate that a single desktop PC left on continuously for a whole year costs approximately £45. In a new school catering for around 1000 pupils, having at least one laptop for every 2 pupils would require the school to have 500 computers in total. If they are continuously left on, this equates to an annual electricity bill of £22,500.

It should also be noted that advancements in technology continue to influence the way ICT is used in offices and schools. A school library for example may only require basic computer facilities. Multiple stand-alone PCs with powerful processors and internal hard drives require more electricity and produce more heat. Likewise, large screens in excess of 17 inches may not be necessary for internet and word processing applications. The proportional and intelligent provision of hi-tech low-energy ICT is clearly an area where design teams and ICT providers need to work together to produce more efficient buildings and services.

In a paper by Chen *et al.,* (2006) they explore what opportunities exist to reduce energy consumption in a large 40 storey office building. Various aspects of the building were examined including the thermal performance of the external surfaces (U-values of walls, windows etc). The mechanical systems which maintain the internal conditions (temperature, ventilation etc) were also evaluated. Using computer software, these specifications acted as input variables which produced an estimated annual energy consumption figure of 9.21GWh. At this stage it was then possible to identify opportunities to optimise the mechanical operations (cooling systems, variable speed pumps, more efficient fans, lighting adjustments etc.) The software then re-calculated energy consumption to be 8.6GWh per year, a saving of 6%. Specific upgrades included improving the lighting system which yielded the largest (technological) efficiency saving.

Another study by Junnila (2007) examined the lighting intensity of four similar commercial buildings across Scandinavia. Normalised electricity performance ranged from 35 to 39 kWh/m². After their analysis, the range reduces to between 13 and 27 kWh/m². Behaviour change was also identified as one area where immediate savings could be made by switching machines and lights off when not in use.

Applying these recommendations to the actual consumption profiles produced a variety of theoretical savings. Most significantly, the first building's ICT demand was 27kWh/m² which then dropped to a mere 5kWh/m². Indeed, when calculating the average lighting efficiency savings through behaviour change (not equipment upgrades), a further 10kWh/m² was identified in all four buildings. The general conclusion reached by Junnila (2007) advances the importance of behaviour change. In this regard, the formative years during which children attend school represent an important opportunity to raise awareness and ensure future generations utilise energy more efficiently than at present.

Dimoudi *et al.,* (2009) conducted a similar study which investigated the heat demand of 9 schools in Greece. Normalising in the usual way based on total floor area, they found that demand ranged from 95 kWh/m² to 150 kWh/m². Unsurprisingly, the schools which used the most energy for heating had the poorest insulation materials. Furthermore, the diesel oil used as the main heating fuel accounted for around 90% of total energy consumption across all 9 schools. Replacing the oil-based systems was not considered. Instead, the analysis looked at ways to optimise energy by modifying the existing systems. During winter months when demand for space heating is highest, the analysis concluded that improving insulation would deliver the largest savings. Similarly, in summer months, a night time ventilation strategy was identified as the most effective strategy to employ.

In all three studies it should be remembered how the analysis was mostly theoretical. In practice, behavioural measures to reduce energy consumption may be forgotten. Likewise, technological efficiencies will require some form of annual or continual commissioning to ensure optimum performance is maintained. The approach taken in this research has therefore been to compare energy efficiency before and after re-commissioning took place.

2.6 Buildings and Educational Transformation

This section summarizes the academic literature which examines the relationship between the physical environment and education. The BSF programme spoke at length about “transforming” the learning environment. The present research has therefore considered ways and means of measuring and/or quantifying this effect.

Attainment, measured principally by the academic performance of students in national examinations may be determined by a host of factors. The sections which follow have therefore considered a variety of conditions which provide a “suggestive” (as opposed to “causal”) body of evidence that demonstrates an important connection between the condition of the physical environment and the quality of the social and educational outcomes.

2.6.1 Lighting

Woolner *et. al’s* (2007) literature review highlights the link between poor quality educational facilities and poor outcomes for learners. Lighting was an area where for example health related issues such as headaches, eyestrains and fatigue were identified. In addition, Heschong Mahone Group (1999) found that students schooled in natural daylight progressed 20% faster in mathematics tests and 26% faster in reading tests than those deprived of natural daylight. The study examined results across a population of 21,000 students.

Lighting can affect our moods, motivation and sense of well-being according to Ruck (1989) who suggests that natural light can be used to increase productivity and stimulate greater creativity. Hale (2002) also observed that pupil performance improved when working in natural daylight using standard tests. By contrast, the psychological effects from working in closed windowless environments has been shown to cause tension and negative attitudes (Lackney, 1994; Ruck, 1989) which by extension has important implications for the “Change of Use” regulations affecting school refurbishment projects.

Further research which identifies a positive correlation between academic performance and daylight has been reported by Kuller and Lindsten (1992). Indeed Rodgers (1998) identifies how lighting can improve the perceived comfort of students leading to better results both in terms of academic performance and health.

Likewise, Meir *et al.,* (2009, p.204) point out, '*individuals relate differently to both the quantitative properties and non-quantitative qualities of light in different settings*' . The CIBSE Code for Interior Lighting for example only talks about *lux* levels and does not include any "qualitative" assessment about the more textual properties of light and colour. Unsurprisingly, numerous studies demonstrate how daylight positively influences productivity, performance and general well-being (De Carli *et al.,* 2008).

2.6.2 Air Quality

Earthman (2004) identified temperature, heating and air quality as important factors in determining student achievement. Air quality has also been linked to morale and mood, leading to improvements in attendance and attainment (Berry, 2002). Moreover, Fisher (2001) describes how student behaviour can be affected by air quality. Similarly, Rosen and Richardson (1999) consider how air quality impacts the learning experience.

More recently, air conditioning, ventilation and heating systems have been said to cause disruptive levels of noise (Shield and Dockrell, 2004). Furthermore, in a literature review conducted by Higgins *et al.,* (2005) temperature and air quality were identified as important factors in determining the quality and effectiveness of the learning environment. .

Sick Building Syndrome has also become a problem in buildings which have a tightly sealed external envelope. In this respect, children are said to be more susceptible to environmental pollutants as they breathe higher volumes of air relative to their body weights in addition to the fact that their tissues and organs are actively growing (Faustman et al. 2000; Landrigan, 1998).

Rydeen (2003) also discovered that "healthy" schools decrease distractions and allow students and staff to focus on the learning process. Furthermore, Richards (1986) identified asthma as a principal cause for 20% of absences in US Schools. More recently the Environmental Protection Agency calculated that respiratory problems led to over 10 million missed school days per year in

America (Lyons, 2002). In the past, successful legislation has been implemented to protect people from health risks. Building materials such as asbestos, lead-based paints and arsenic are examples where dangerous materials have been banned (Centifonti and Gerber, 1997).

In an extended review of numerous journals, Mendell and Heath (2005), in their paper, *'Do Indoor Pollutants and Thermal Conditions in Schools Influence Student Performance'*, conclude,

> '... *the adverse environmental effects on the learning and performance of students in schools could have both immediate and lifelong consequences for students and for society' (p.3)*

From a UK perspective little published information is available about the effects of the indoor environment on pupils' heath and performance in Schools (Clements-Croome *et al*., 2008). Future research may need to examine how modern buildings accommodate for the improvements in air tightness through their ventilation systems and how this relates to behavioural and productivity outcomes for both staff and students.

2.6.3 Noise

Pegg *et al.* (2005) in their study address how building design impacts noise performance, and similar to the above, identify the limitations imposed by the current building regulations,

> *"Since construction, acoustic guidelines have been reshaped for schools ... These new acoustic guidelines will make an open plan approach to classrooms difficult to repeat in the future." (p.216)*

They further explain how regulatory changes which comply with noise control requirements limit the capacity to create low energy buildings, explaining how the present guidelines gives rise to,

> *" ... mechanical ventilation and cooling, which when coupled with increasing ICT energy use will certainly be unsustainable." (p. 224)*

From an education perspective the literature surrounding noise attempts to distinguish between internal (Woolner *et al.,* (2007) and external (Weinstein, (1979); Rivlin and Weinstein (1984); Shield and Dockrell, 2004) sources of noise disturbance. Skills which relate to language, such as speaking, reading and writing are also said to suffer as a result of noise disturbances.

Interestingly, Knez and Hygge (2002, as quoted by Higgins *et al,.* 2005, p.18) explain how '*irrelevant speech is particularly distracting*' for learners which in part justifies the acoustic-related planning reforms which Pegg *et al.* (2005) previously mention when discussing open plan classroom design. Curiously, one possible irony which may unfold is the noise-related problems associated with mechanical heating and ventilation systems in terms of providing the best possible environment for teaching and learning (PwC, 2007, p.E7).

Evidently, as Higgins *et al.,* (2005, p.18) explain,

> "*A more reliable finding is that chronic noise exposure impairs cognitive functioning and a number of studies have discovered noise-related reading problems (Haines et al, 2001b; Evans & Maxwell, 1997), deficiencies in pre-reading skills (Maxwell & Evans, 2000) and more general cognitive deficits (Lercher et al, 2003)."*

The general conclusion therefore tends to support the view, as Schneider (2002, p.6) confirms,

> '... *good acoustics are fundamental to good academic performance.*"

2.6.4 Educational Performance (attainment)

From a UK perspective, Estyn (2007) assessed students before and after moving into new schools. The research included data from over 70 schools in Wales. Significantly the greatest effect was observed in schools where levels of poverty were highest. It was also noted how primary school children demonstrated a far greater range in performance (-8% to +45%) compared with secondary school children (-5 to +10%). More generally, there is now a consensus of opinion which acknowledges how the early years (1 to 5) of a child's development are critical in terms of shaping their lifelong prospects.

In a study commissioned for the Australian Department of Education, Clark (2002) distinguishes between structural and cosmetic design factors.

Structural Elements: *Building Age, Windows, Flooring, Acoustics, Air-conditioning, Locker Conditions, Ceiling Material, Equipment, Lighting, Noise, Student Density (m2/student), Site Acreage.*

Cosmetic Elements*: Interior Painting, Exterior Painting, Floors Swept, Floors Mopped, Graffiti, Furniture, Landscaping.*

In a similar vein, Cash (1993) identifies how air conditioning, absence of graffiti, condition of science laboratories, locker accommodation, condition of classroom furniture, wall colour and acoustic levels; all correlate with student achievement whilst controlling for external socio-economic factors..

Interestingly, when the researcher was liaising with experts in the field of building performance, Roderic Bunn from the BRSIA explained how,

> "... *the one area we do need to know more about is the effect of occupant density on usability and occupant satisfaction. Certain buildings seem to stall or fail when certain densities are reached." (personal communication)*

Indeed, with the UK population increasing, the growing demand for school places may well mean that buildings of a multi-storey nature will be required in urbanised environments. Moreover, the findings presented in the PwC (2007) 'technical report' indicate that whilst evidence exists which identifies the educational benefits from improving inadequate or dilapidated conditions, learning environments which go beyond 'fit-for-purpose' do not appear to continue this trend.

From a different perspective, Crampton (2007) looks at how different types of investment including infrastructure renewal can improve student achievement, at the same time as introducing the notion of "capital" as a way to conceptualise the different challenges.

"*Not surprisingly, investments in teacher compensation (human capital) and instructional support (social capital) demonstrate larger effects than investments in school infrastructure (physical capital), but all were statistically significant, and hence all are necessary to enhance student achievement.*" *(p.4)*

Furthermore, Earthman *et al.* (1995) observed that students achieved between 1 and 11% higher in tests from well designed buildings compared with poorly designed buildings, a finding which Cash (1993) also identified. Interestingly, a study by Maxwell (1998) links the disruption caused by renovation work with faltering academic performance, a problem most likely to affect refurbishment projects.

Similarly, Earthman (2004) reminds us that although "inadequate" buildings contribute to poor student performance, there is insufficient evidence to suggest the learning environment need be anymore than "adequate". Likewise, Stricherz (2000) and Hanushek (2003) find no empirical evidence to suggest student attainment continues to increase when the teaching environment improves beyond what is necessary. In addition, Bowers and Burkett's (1989) identify how students who attend modern buildings tend to outperform those students from older buildings.

Finally, given how research on educational performance is both mature and diverse, it has been useful to summarize the major findings set out in the PwC (2007) "technical report" which were based on the review of educational literature carried out by Woolner *et al.,* (2007).

OUTCOME	Improvements in design/ environment = improved impact	Poor quality design / environment = detrimental effect	Unclear evidence on impact
Attainment	Light (day light) Build quality (pathways and positive outdoor spaces)	Air quality Noise Safe healthy surroundings	Room arrangements
Engagement	Low ceilings Colour (contrast walls) Storage (open shelves, more time on task)	Air quality Noise	Ergonomic furniture Noise Temperature / ventilation Air quality Desk arrangements
Affect	'Beautiful' spaces High ceilings (teacher satisfaction) Display (pupils self-esteem)	Overall build quality Noise	Colour Lighting Noise (Mood) Build quality (renovation)
Attendance		Air Quality Safe, healthy surroundings	Temperature Ventilation Build quality (ownership versus short-term 'Wow factor'

Table 5. Impact of design attributes on teaching and learning outcomes (PwC, 2007)

2.6.5 Attitudes to Learning (behaviour)

Whilst the evidence which links facilities to attainment could be loosely described as inconclusive, it is also necessary to form a judgement about the way attitudes to learning can be improved through infrastructure investment. Measuring attitudes to learning may well require a mixture of both quantitative and qualitative data. Earthman (1995) for example observed how school buildings with fewer disciplinary incidents tended to be in better condition. In a follow up study, Earthman (2004) reported a decline in pupil morale when buildings were described as "inadequate".

Two reports by PwC (2004, 2007) identified how the majority of parents, pupils and staff felt that new buildings had a positive effect on behaviour and attitudes. From the staff perspective, issues such as morale, job satisfaction and teacher absenteeism were found to be adversely affected by inadequate or dilapidated conditions (Corcoran *et al.,* 1988). Moreover, Fink (1997) identifies how new schools have cultivated a shared view of education where relationships between staff and students become stronger. Perhaps, unsurprisingly, Glickman (2004) found that students in the US were more likely to complain about building conditions than curriculum standards.

Indeed, whilst it is not clear how attitudes and behaviour are shaped by particular aspects of the physical environment, the evidence tends to suggest that poor young children may be more affected by the condition of their environment. In this regard, the BSF programme was justified in terms of prioritising local authorities and communities where there was clear evidence of socio-economic distress compounded by inadequate facilities.

2.6.6 School Size (pupil numbers)

Firstly, what constitutes a small or large school depends on which country you are referring to. Looking at some of the studies from the US where large schools may contain thousands of students, Keller (2000) found that small schools (<1000) were consistently more successful based on evidence collected from a sample of 13,000 schools. From an "engagement/relations" perspective, Schneider *et al.,* (2000) identified that small schools were also more effective when communicating with parents. In a UK study, Garrett *et al.* (2004) suggest there might be an optimum school size that allows the advantages of both large and small schools to be realised at the same time. The following scenario may help to explain this idea.

At present the evidence tends to suggest smaller schools have better results. In addition, Walsey *et al.* (2000) identify that smaller schools allow increased intimacy, which in turn, fosters closer ties between staff and students [social capital]. The Public Agenda (2002) research confirm that two-thirds of parents interviewed felt that smaller schools offered a greater sense of community, are less likely to obscure poor teaching and were better placed to deliver personalised learning.

If the reality of funding limitations make small schools unaffordable, then it follows that larger schools need to be designed and managed in a way that facilitates a small school “culture”. At Oxford and Cambridge for example, the universities have adopted a collegiate system; large schools may wish to adopt a similar approach. In this regard, the social architecture of a school becomes an area where research may wish to examine the relationships between building size and pupil numbers with attainment , behaviour, or indeed energy consumption.. Indeed, it may transpire that more energy (kWh) consumption per pupil has wider societal benefits over the long term, thus highlighting the need to de-carbonise the supply through renewables and nuclear.

2.6.7 Class size

Surprisingly, after many years of formal education the optimum class number still remains unclear. Some possible reasons include the expansion of the national curriculum and the inherent differences which exist between teaching and learning different subjects. A Mathematics lesson for example may be vastly different from an English lesson. More recently, class room assistants have become more common in UK schools which helps to share the work load. Even more notable is the emergence of ICT as a mainstay of modern classrooms, for as Dasgupta *et al.,* (2012) explain,

> “*A significant challenge facing school energy is the growing numbers of ICT in teaching areas. ICT solutions have evolved from being used in ICT suites alone to being spread over teaching zones in a pupil to device ratio of 1:3 and 1:1” (p.11)*

Moreover, given the funding discrepancy which exists between the public and private sector, as Dudek (2000) explains,

> "*Private fee-paying schools within the UK invest around £5,000 per pupil per year with staff ratios below 10:1. In the state sector the figure is currently in the region of £2,250 per pupil with staff ratios double or triple that" (p.131)*

Interestingly, the research evidence does not categorically favour smaller class sizes. Hanushek's (2003) meta-analysis for example demonstrates that class size has no impact on attainment, corroborating other studies which reveal the same finding (Hoxby, 2000; Johnson, 2000). At the same time, the PWC 'technical report' (2007) concludes by suggesting,

> *"... the weight of evidence indicates to us that smaller classes do result in higher student achievement..." (p.E4)*

Indeed, with a greater emphasis on personalised learning (delivered through ICT), more research that considers the impact from technology needs to be carried out as circumstances continue to change.

2.6.8 ICT and Education

Becta (2003a) identified how ICT had a positive impact on student motivation, confirming findings from similar studies (Watson, 1993; Cox, 1997; Denning, 1997; Passey *et al.,* 2004).

Studies (Miller *et al.,* 2004; Higgins *et al.* 2005) which examine the educational outcomes from using Interactive whiteboards (IWB) found that pupil-teacher interaction was enhanced, and attainment for low performing students was marginally improved, although the statistical tests did not yield conclusive evidence.

Additional factors which determine the quality of ICT provision include most notably, the competence of staff to use ICT (Cox *et al.,* 2003). One study by Harrison *et al.,* (2002) examined how GCSE scores were linked to students with varying degrees of ICT knowledge. Whilst the results proved only moderately significant, the emerging pattern supports the view that improved skills when using ICT (E-maturity) translates to better overall student performance.

Building on this research, Somekh *et al.* (2007) carried out a longitudinal study which included primary, secondary and further education institutions. They discovered how investment in technology had a positive impact on student attainment. They also identified how teachers were better able to manage their workload and provide improved support for students. Future research may wish to evaluate ICT competence across the teaching profession, possibly looking to determine how older teachers adapt their skills to include new technology. Obviously there will be differences in the application of ICT across the range of different subjects. It may therefore be sensible to compare and contrast how different core subjects such as Maths and English choose to employ ICT.

2.6.9 People and Buildings

Schneider (2002) highlights the difficulty of isolating "causal" variables in determining attainment and behaviour. In addition, the personal traits and characteristics each teacher brings to their profession makes empirical analysis more difficult. Woolner *et al.,* (2007) captures this reality when she explains,

> "... *the relationship between people and their environment is complex and therefore any outcomes from a change in setting are likely to be produced through an involved chain of events. It is the defining and understanding of these mediating chains that is key and must take account of issues relating to ownership, relevance, purpose and permanence." (p.61)*

Al-Enezi (2004) has developed a simple theoretical model to understand how these "mediating chains" operate. Three statements are presented below which set out the underlying assumptions.

1. Leadership and financial ability influence how well a building is maintained, which in turn has a corresponding effect on building conditions.
2. Building conditions affect the attitudes of pupils, teachers and parents.
3. The attitudes of teachers and parents subsequently influence pupils' attitudes to learning and behaviour more generally.

Furthermore, figure 11 illustrates how the management of the physical environment could potentially affect student behaviour.

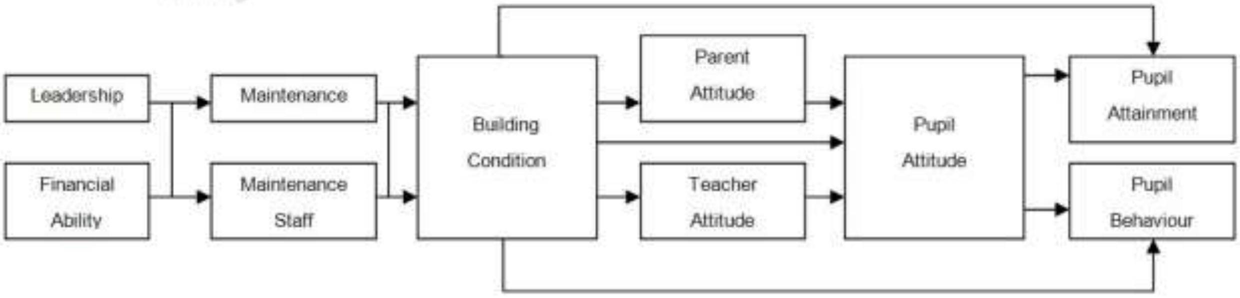

Figure 11. Environment and Pupil Behaviour Model (Al-Enezi, 2004)

In this regard, Clark (2002) identifies the importance of developing new schools by working closer with the staff who use them. Adopting a more "participatory" approach in terms of involving teachers throughout the design phase will hopefully translate into better design solutions. Equally, the relationship between teaching staff and the out-sourced FM provider is an area of contention which the Soft Landings case studies draw attention to.

Traditionally, school caretakers (now known as 'Business Managers') were typically the first point of contact when problems arose. More recently, business managers act as the interface between the school and the FM provider, making sure that services operate according to the terms of the contract. It is therefore hoped that FM providers will learn to work closely with schools to ensure common goals such as efficiency measures and occupancy satisfaction are optimised and maintained.

More generally, it will be necessary to consider how policy and building regulations can be adjusted to ensure both attainment and behaviour outcomes improve. Indeed, from an energy perspective, Dasgupta *et al.,* (2012) explain, “*Building Bulletins form a part of the construction contract. They can inhibit the process by providing absolute requirements. An example of this is the absolute figures proposed by BB101 to avoid overheating in schools. Single figure summertime temperatures are not deliverable via the use of pure natural ventilation strategy cooling as this tends to deliver a temperature range relative to the outside temperature... as a result there is an increased tendency to adopt mechanical and energy intensive solutions to meet the rigid criteria specified in building bulletins.” (p.10)*

Evidently, greater flexibility to relax particular aspects of building regulation may need to be considered, especially for projects which have been ear marked as “innovative” or “zero-carbon”.

2.7 Procurement Practices in the Construction Industry

Procurement and construction practices are very much interlinked. Over the past 10 years PFI contracts have emerged which enable the government to borrow money from the private sector to fund large infrastructure projects. Mark Dudek, in his book ‘Architecture of Schools’, published in the year 2000, explains how these funding mechanisms may also change the balance of power within the construction industry,

“As procurement strategies evolve it is likely that architects will become more integrated into the construction team of surveyors, engineers and landscape architects all employed by the main contractor.” (Dudek, 2000, p.131)

He does indicate however that project management systems will need to adapt to democratise the design process,

“Today [2000], the procurement process is moving towards new levels of transparency where everyone should have a stake in determining how public funds are allocated. The contemporary debate only has meaning if the dual criteria of value for money and community involvement are part of that process” (Dudek, 2000, p.73)

In this regard, a sustainable school needs to realise this “dual criteria”, at the same time as reducing running costs through energy efficient designs.

Looking briefly at the academic literature which examines circumstances through which innovation is promoted has important implications for the way procurement systems prioritise energy efficiency and sustainable development. Howards and Caldwell (2011) suggest that innovation occurs when long term interactions (relationships) develop across a broad spectrum of interest groups or stakeholders. From a sustainability perspective, Horbach (2008) suggests that the client’s interests and priorities will play an important role in terms of influencing the design process.

According to Rohracher (2001), the ‘user’ i.e. teachers in a school, have a wealth of knowledge based on working in a particular environment on a daily basis. According to Barlow (2000), extracting this type information can be more effective when the management structures are less hierarchical, which in turn help create a more open platform to communicate. However, as the PWC (2007) report confirmed, less than 20% of BSF projects involved the “direct” involvement of “classroom” teachers. Furthermore, as Woolner (2010) comments,

> *“Difficult though it is to quantify how much time, or other evidence of involvement is ‘enough’, it is concerning if people across the school community do not seem to be or feel themselves to be part of the process. This undermines the ideal of collaborative design and threatens the fundamental aim of development occurring through users understanding the school setting and their contribution to it. This would seem to constitute a real threat to any hopes of transformation within education.” (p.83)*

Indeed, with the time it takes to carryout thorough and effective client consultation, Dudek (2000) reminds us that,

> “*Clients [Schools & Local Authorities] inexperienced in this role may be surprised at the overall length of time it takes to brief adequately... Time consuming it may be, but good briefing is a two-way process which will pay immense longer-term dividends” (Dudek, 2000, p.128/129)*

Leiringer (2006) further highlights the importance of contracts in the construction industry as central to incentivising innovation in the design process. A lack of operational targets for energy efficiency has been an issue which the BREEAM requirement failed to address. However, due to the scale, cost and permanence of constructing buildings, traditional methods are generally preferred within the construction industry as the project risks are easier to predict (Intrachooto and Horayangkura, 2007). In the absence of regulatory targets for operational (energy) performance, it may be necessary to identify particular projects where innovation should be encouraged through increased capital funding and the acceptance that such projects carry greater commercial risks.

To shed more light on the particular areas where project "risks" exists, Rintala (2004) produced the following table (6).

Table 6. Types of Risk (Rintala, 2004, p.40)

Risk	Description
Design Risk	The risk that the design will be unable to meet the performance and service requirements in the Output Specification. This includes issues such as build-ability, fitness for purpose, and functionality of the proposed technical solutions.
Technology Risk	The risk that changes in technology result in services being provided using non-optimal technology.
Construction Risk	The risk arising from the uncertainty that the project will be delivered to agreed specification, schedule and budget.
Operational Risk	The risk that operating costs vary from budget, that the performance standards slip, or the service cannot be provided.
Energy Risk	Energy risk is divided into *Energy Consumption Risk* and *Energy Price Risk* • Energy Consumption Risk: the risk that the building's operational energy consumption is beyond agreed standard for maximum annual energy consumption in the contract. • Energy Price Risk: the risk of fluctuations in the market price of energy.
Maintenance Risk	The risk that the cost of keeping the asset in good condition varies from budget.
Planning Risk	The risk that the implementation of a project fails to achieve the terms of planning permission, or that detailed planning permission cannot be obtained, or, if obtained can only be implemented at costs greater than in the original budget.
Regulatory/Political Risk	The risk arising from legal changes and changes in government.
Environmental Risk	The risk that the project will have adverse environmental impacts beyond permitted limits. This may be the result of environmental changes and regulations.
Financial Risk	The risk arising from inadequate hedging of revenue streams and financing costs. Included in this category are issues such as refinancing of the project, the stability of the local currency, and taxation issues.
Revenue Risk	The risk that revenue gained from the project over the project term varies from initial expectations. It includes ownership risks such as the construction of a competing facility or premature obsolescence.
Project Default Risk	The risk that the Private Sector Partner or its subcontractors are unable to fulfil their contractual obligations through a combination of any of the other risk categories.

However, as Dudek (2000) explains, the experiences from history highlight a mixed picture,

> "*Where optimum risk transfer can be achieved, both the public and private sector are in theory able to concentrate on those activities they do best. As can be seen in the case of some of the privatized railways in the UK, this can also mean that the service deteriorates although direct costs to the taxpayer remain fixed, thus achieving one side of the equation. In the case of school projects, the operation is usually more controlled and less susceptible to cavalier management techniques. Nevertheless, considerable resistance to this new approach can be discerned. Many believe it has long-term cost implications far in excess of conventional approaches to funding." (Dudek, 2000, p.124)*

Looking more closely at the funding aspect of the BSF programme, Partnerships for Schools was the agency setup to manage and administer the procurement strategy. Their job was to help local authorities develop a vision and select private sector partners who could deliver the new secondary schools as part of a cost-effective single contract package. In Leicester, the BSF programme would involve the redevelopment of 16 to 17 secondary schools, over a 10 year period with an approximate budget of around £230 million, equivalent to £15 million per school.

Interestingly, Dudek (2000) remarks how,

> "*... an ethos of competitive bidding for relatively limited funds will ensure that value for money, community involvement and flexibility within new school environments is incorporated into the development process. Ultimately, well-funded and well-managed schools will help to provide higher standards of education and lifelong learning for the whole community. In future, the emphasis may be on the school community itself determining the way in which their facilities will develop."*

Out of the four phase one "sample" schools in Leicester, the smaller projects adopted the standard "Design and Build" contracts using conventional funding from government. The larger more ambitious schools however, employed the newly developed BSF-PFI model where conventional funding is replaced by PFI credits using the Funding Allocation Model (FAM) which looks at pupil numbers, floor area (m^2), 'abnormal' construction costs, regional variation in building costs, ICT per pupil, etc before setting a project budget. Subsequent reports which investigated the quality control side of the BSF programme revealed a number of concerns regarding the quality of PFI schools (CABE, 2007). Based on these findings, phase 2 projects were supported by CDAs - specialist independent architects.

Looking finally at the range of contracts in existence today, table 7 provides details of each approach.

Table 7. Public Private Partnerships (Gunnigan, 2007, p.5)

Type	Description	Transfer of title	Duration of Partnership
Operate and Maintain (O&M)	Private sector organizations enters contract to operate a public sector facility on behalf of a public sector organization over an agreed period of time.	Remains with public sector organization for duration of the contract	For duration of contract
Design & Build (D&B)	Private sector organisation enters contract to design, build and provide construction finance for a public sector project. Public sector organisation pays agreed contract sum on completion of the construction phase.	On completion of construction	On transfer of the title
Build Lease Transfer (BLT)	Similar to D&B except that the public sector organisation pays for the project over a long-term lease.	On completion of payment of lease	On transfer of title
Design Build Finance Operate (DBFO)	Private sector organisation enters contract to design, build, finance, and operate a public sector facility over an agreed period. Private sector organisation recovers its investment over the contract period through payments by the public sector organisation for services delivered.	Remains with public sector organisation for the duration of the contract	For duration of the contract
Build Operate Transfer (BOT)	Private sector organisation enters concession contract to design, build, finance and operate a public sector facility over an agreed period. Private sector organisation recovers investment over the contract period under the pre-negotiated contract terms. The concession period is usually significantly shorter than the operating life of the facility	At the end of the contract period	On transfer of title
Build Own Operate (BOO)	Private sector organizations enters concession contract to design, build, finance and operate a public sector facility for as long as the economic operating life of the facility.	Remains with public sector organisation in perpetuity	For duration of the contract

The BSF-PFI contract follows the "DBFO" model which Dudek (2000) describes as follows,

> "*A private contractor, sometimes linked to a new commercial development, constructs and operates a school building for an agreed period of time. The numbers of new school pupils can be clearly assessed, therefore the need is tangible [FAM]. The contractor receives a performance-related operating fee to cover borrowing, running costs and profit. Capital outlay is funded privately, therefore funding and operating responsibility is taken*

away from the LEA... Facility management schemes are those where a specialist private contractor takes responsibility for providing a service such as heating or grounds maintenance. Here the contractor will not only provide the fixed asset such as a heating boiler, but will also agree to provide heating for the buildings to a stated temperature range over a set contract period. These agreements can be handed on to PFI (p. 124/125).

Furthermore, as Broadbent and Laughlin (2002) explain, PFI projects do not feature on the balance sheets of public sector spending until such time as the contract expires. Typically contracts last anywhere from 10 to 30 years during which time the private sector consortium effectively owns the schools. Understandably, this ‘market’ style approach to fund public investment has generated a lot concern over the long term costs to the tax payer. However, according to the NAO (2001), PFI projects tend to complete on time and on budget when compared with similar non-PFI projects. Furthermore, additional research carried out by the DfES (2005) identified the following performance outcomes,

- 70% of non-PFI projects were late
- 73% of non-PFI projects were over budget, whilst,
- 90% of PFI projects completed on time.

In summary, the complexity of the procurement system should not be underestimated. Innovative solutions which prioritise energy efficiency and promote sustainable lifestyles need to become a central part of the design and procurement process.

The final section of this review examines the literature surrounding Systems Theory and the way Sustainable Development can play a role in shaping future policy and regulatory reform..

2.8 Systems Thinking

Coley (2009) has identified 8 approaches to systems thinking which demonstrate how sustainable development can be linked to the BSF programme.

Table 8. Approaches to Systems Thinking (Coley, 2009, p.14)

Product Service System	An innovation strategy, shifting the business focus from designing physical products only, to designing a system of products and services which are jointly capable of fulfilling specific client demands	*Manzini and Vezzoli, 2003*
Eco-Efficient Product Service System	When a Product Service System assists to reorient current unsustainable trends in production and in consumption practises	*Manzini and Vezzoli, 2003*
Eco-Efficient Service	Eco-efficient services are systems of products and services which are developed to cause a minimum environmental impact with a maximum added value	*Brezet et al., 2001*
Whole System Design	WSD means optimising not just parts but the entire system ... it takes ingenuity, intuition, and team work. Everything must be considered simultaneously and analysed to reveal mutually advantageous interactions (synergies) as well as undesirable ones	*Rocky Mountain Institute, 2004*
Solution Oriented Partnership	A sustainable system of products and services delivered in a highly effective way by a network of local and global partners which is able to address specifically each given user in its given context.	*Manzini, 2003*
Integrated Solution	Integrated solutions combine products and services into a seamless offering that addresses a pressing customer need	*Wise and Baumgartner, 1999*
Advanced Industrialised Solutions	Solutions based on collaboration between social players that give rise to highly contextualised services (services that are sensitive and appropriate to the specific characteristics of the contexts in which they are provided), which are also equally effective and efficient (able to offer high quality results while minimising economic and environmental costs)	*Manzini, 2003*
Customer solutions	Typically developed as a combination of products, services, and knowledge, a solution is a supplier's customised response to a customer's pressing business need. It is an innovative construct built on a foundation of cooperation and mutual trust that revolutionises the customer value proposition	*Cornet et al., 2000*

From a global environmental perspective, new buildings will be expected to reduce their overall carbon footprint which requires a new way of thinking. Coley (2007) suggests a systems approach needs to consider both environment and context when formulating a proper understanding of a problem.

Traditionally, as Coley and Lemon (2009) explain,

> "*The lone ingenious designer, who could do everything by himself or herself is rapidly becoming history (Krippendorf, 2006). Design research suggests that the development of more innovative and sustainable solutions increasingly requires the integration of multiple actors with an expansive array of knowledge and expertise. The importance of cross-disciplinary collaborations and partnerships within industry is escalating, driven by the need to address complex problems more systematically..." (p.544)*

Similarly, Seiffert and Loch (2005) explain how the inter-connected dynamics of a system's component parts is what determines its complexity. Likewise, Coley (2009) identifies how a holistic approach to problem solving cannot always rely on conventional methods.

> "*A complex problem is typically broken down into its component parts before being able to systematically solve the problem piece by piece. Whilst this is powerful for some problems, not all components of a problem can be looked at independently. This is one of the reasons why the development of more sustainable solutions is said to require a shift in design mentality" (p.42)*

The Public Private Partnership (PPP) in conjunction with a PFI funding model was seen as a mechanism through which closer collaborations could begin. It has therefore been interesting to consider how the development of a conceptual framework could support a more coherent policy vision for sustainable schools. Moreover, as attainment and community engagement were central themes of the BSF programme, Mont's (2006) 'Product Service System' description could be one theoretical model to consider.

> "*A Product Service System suggests the need to link hard and soft issues such as technology and sociology, products and services and to view existing environmental problems from a systemic perspective" (Quoted in Coley & Lemon, 2009, p.545)*

Prior to the notion of a Sustainable School, extending services to the local community was seen as a move helpful way to ensure maximum benefit and value for money. In this regard, the school acts as the focal point, a "hub" which facilitates greater interaction between community members.

Likewise, Coley (2009) highlights the importance of interactions between the professions,

> "*... the development of more innovative and sustainable solutions increasingly requires integration of multiple actors with an expansive array of knowledge and expertise" (p.11)*

Including the views and opinions of the wider community as part of the visioning and design phase was suggested by Dudek (2000). The BSF programme makes novel references to the "output" specification – the brief which captures the important needs and wishes of the client. In this respect, the final solution resembles the "solution oriented partnership" model as described previously in table 7.

Rebuilding the nation's schools was characterised as a panacea for arresting society's dysfunctions. Likewise, the promotion of sustainable development as a blue print for society would help to link the local challenges with those that exist throughout the world (climate change, poverty, malnutrition etc). In a holistic sense, Anarow *et al.,* (2003) also explains how 'Whole System Design' challenges the orthodoxies of the past,

> "*Whole-system thinkers see wholes instead of parts, interrelationships and patterns, rather than individual things and static snapshots. They seek solutions that simultaneously address multiple problems." (p.10)*

At the conceptual level, it has not been possible to identify an existing framework for schools that could be described as 'systemic' or 'hollistic'. It has therefore been important to consider how the case-study analysis, in combination with the literature review can be merged together to create a new model for schools which address the multitude of competing social, educational and environmental issues at stake.

At the same time, the ability to accurately measure these outcomes demand a multi-disciplinary approach. However, whilst a holistic approach may offer particular advantages in terms of developing a big-picture understanding, the actually practical benefits from employing a more systems approach can potentially threaten the clarity of what needs to be done.

"*It remains unclear how successful each approach [table 7] is at producing significantly more environmentally sustainable results. This lack of clarity is due to the limitation in the number of examples that exist... future research would benefit from quantifiable studies exploring and comparing the sustainable quality of the results for these design approaches." (Coley, 2009, p.29)*

From a commercial perspective however, contractors who willingly adopt knowledge management systems may also find that feedback collected throughout the design-build-operate cycle helps to deliver commercial advantage through improving their products and services. More recently, the evidence accumulated from over 40 years of POE studies consistently demonstrates the value and importance of feedback when developing new processes and systems.

Further commentators from the systems literature highlight how public and private partnerships are more likely to produce better services and products when they work together (Stempfle and Baedke-Schaub, 2002). Similarly, Dong (2005) suggests that the whole team needs to understand the key objectives, processes and intended outcomes in order to achieve the required success. Defining Sustainable Development in context has created problems however. Kleinsmann and Valkenbury (2008) for example highlight how multi-disciplinary teams interpret words differently. Indeed, a report produced by the Westminster Sustainable Business Forum (WSBF, 2008) which examined the BSF programme identified a "lack of common language" as one reason why the "educational transformation" agenda became a "white elephant" in the eyes of many BSF participants. This perceived ambiguity was also echoed in a House of Commons report (2007), titled, *'Sustainable Schools: Are we building schools for the future?'* when they raise various questions about the purpose of the BSF programme,

"*The crucial question here, and one that the Department has not fully answered, is what do we want education to be in the 21st century?... Does it mean enabling children to attain at a higher level using current measures of achievement [GCSE/A-Level etc]... or does it mean taking a more fundamental look at how children learn and what they need to learn, and provide facilities to enable that to happen?" (p.4)*

In the absence of a “comprehensive” vision for Sustainable Schools, one which achieves broad political consensus and where the full spectrum of concerns are taken into account, the proliferation of multiple definitions and conceptions (including this project) will continue.

Commentators who for example raised doubts about the Educational Transformation agenda put forward their reasons in the House of Commons report.

> “*I think buildings are not the answer to transformation in education. They can assist and they can remove obstacles to a more flexible curriculum and so on, but they form part of an education vision which is also very much to do with leadership... because schools, of course are not factories... they are places where human interaction takes places, and therefore all the factors which affect the quality of human interaction are important” (The Director of Place Group, p.37)*

Supporting this position, a Head Teacher interviewed as part of the PwC (2007) BSF report made the following comments,

> “... a *new building might put 5% on the results but it’s not going to transform results. The key is the systems and structure you put in place. The buildings can facilitate that.” (p.77)*

According to Coley (2008), traditional hierarchical structures where separation exists has been said to inhibit the development of ‘private non-codified knowledge’ (aka, tacit knowledge). At the same time, when a client has little knowledge about the construction process, these limitations need to be accounted for by increasing the level of support (e.g. appointing a “CDA”). An effective partnership between various stakeholders will thus rely on open and honest communications. Furthermore, O’Connor and McDermott (1997) identify how conventional problem solving looks at one-on-one cause and effect relationships. A systems approach seeks out inter-connections as part of a network, attempting to capture and simulate the real world.

2.9 The Five Capitals Model – a Framework for Sustainable Development

The Five Capitals Model promotes the view that wealth creation and environmentalism must operate as 'one' through reforming the mechanism of capitalism to create a sustainable future. Its contribution has therefore been to conceptualise Sustainable Development as 5 interdependent "capitals" . From a systems perspective, "capital" represents the accumulation of wealth – a dynamic outcome that relies on a variety of "inputs" and "processes" across the 5 capitals which (hopefully) provide the optimal conditions for sustained prosperity and good health.

According to Forum for the Future[4],

> "*Any organization will use five types of capital to deliver its products or services. A Sustainable Organization will maintain and where possible enhance these stocks of capital assets, rather than deplete or degrade them."*

Capitalism was originally founded on the notion there were two types of capital – 'money' and 'goods'. More recently, there has been an explicit acknowledgement that 'people' and 'nature' are also stocks of a less tangible kind, but are essential components towards building a better quality of life. In this regard, the 5 Capitals Model looks to combine the "physical" world with the "social" world, two fundamental concerns which are central to the BSF programme.

Forum for the Future explains how the 5 capitals model can,

> "*... allow organizations to develop a vision of what sustainability looks like for its own operations, products and services.... however, an organization needs to consider the impact of its activities on each of the capitals in an integrated way in order to avoid 'trade-offs'. Using the model in this way for decision-making can lead to more sustainable outcomes."*

It has therefore been necessary to consider each capital individually, and how a new model that is tailored for a school can be developed.

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[4] http://www.forumforthefuture.org/sites/default/files/project/downloads/five-capitals-model.pdf

Natural Capital, is presented first and is therefore assumed to be the original source of all wealth. Services such as clean water, arable land, fresh air, fisheries, forests etc, are all part of the planet's stock of natural capital.

The next capital to be presented is **Human Capital** which combines both the skills and knowledge we draw upon to create a more joyful and spiritual existence. From a commercial perspective, Forum for the Future explain why this is such an important feature of a successful organization,

> "*Organizations depend on individuals to function – they need a healthy, motivated and skilled workforce, for instance. Intellectual capitals and knowledge management is increasingly recognisable as a key intangible creator of wealth..."*

The third capital is connected with human capital but considers the value of relationships within communities and across society more generally. This we call **Social Capital**. Forum for the future differentiates between two types of Social Capital,

> "***Internally****: Social capital takes the form of shared values, trust, communications and shared cultural norms which enable people to work cohesively and so enable the organisation to operate effectively.*
>
> ***Externally:*** *Social structures help create a climate of consent, or a licence to operate, in which trade and the wider functions of society are possible. Organisations also rely on wider socio/political structures to create a stable society in which to operate."*

Manufactured capital can be seen to represent the culmination of natural, human and social capital, described as,

> "*... the material goods and infrastructure owned, leased or controlled by an organisation that contribute to production or service provision, but do not become part of its output. The main components include buildings, infrastructure (transport networks, communications, waste disposal systems) and technologies (from simple tools and machines to IT and engineering)"*

Buildings in particular have a symbolic function representing the wealth and prosperity that accumulates over many centuries to reflect the success of a country or civilisation. The iconic twin towers in New York were symbolic of America's success in the 20th Century and capitalism more generally.

Financial capital (or money/credit) is a familiar concept as we use this everyday through the purchases and transactions we make. Unlike the other capitals however, Porritt (2005) explains that financial capital,

> "*...has no intrinsic value; whether in shares, bonds or banknotes, its value is purely representative of natural, human, social or manufactured capital." (p.139)*

More importantly, the 5 capitals model has proven to be an important thematic framework which has guided the research. Similar models of sustainable development have been considered but did not project the same degree of inter-connectedness and flexibility. Other frameworks which attempt to capture the notion of Sustainable Schools were also considered. Take for example the 8 Doorways Framework which the DCSF created.

1. Food & Drink
2. Energy & Water
3. Travel & Traffic
4. Purchasing & Waste
5. Buildings & Grounds
6. Inclusion & Participation
7. Local well-being
8. The global dimension

The first thing to note was the lack of any natural or environmental doorway. There was also no hierarchy or connectivity in evidence. Should the "global dimension" have primacy over the others? And were these 8 doorways politically contrived?

Another Sustainable Schools Framework was developed by the Qualifications and Curriculum Authority (QCA) as presented by Goodfellow & Andrew-Power (2008). 7 key concepts were identified.

1. Interdependence – of society, economy and natural environment, from local to global.
2. Citizenship and Stewardship.
3. Needs and rights of future generations.
4. Diversity – culturally, socially, economically, and biologically.
5. Quality of life, equity and justice.
6. Sustainable change – development and carrying capacity.
7. Uncertainty, and precaution in action.

In both frameworks there was no attempt to develop a system of interconnected parts. Under these circumstances, it has fallen upon the current research to envisage a more organic conceptualisation; one which links together the key themes and processes.

In one report by Professor David Pearce (2003), titled, *'The Social and Economic value of Construction'*, as his schema diagram below illustrates, a "capitals" approach has been used to evaluate the construction sector's contribution to Sustainable Development.

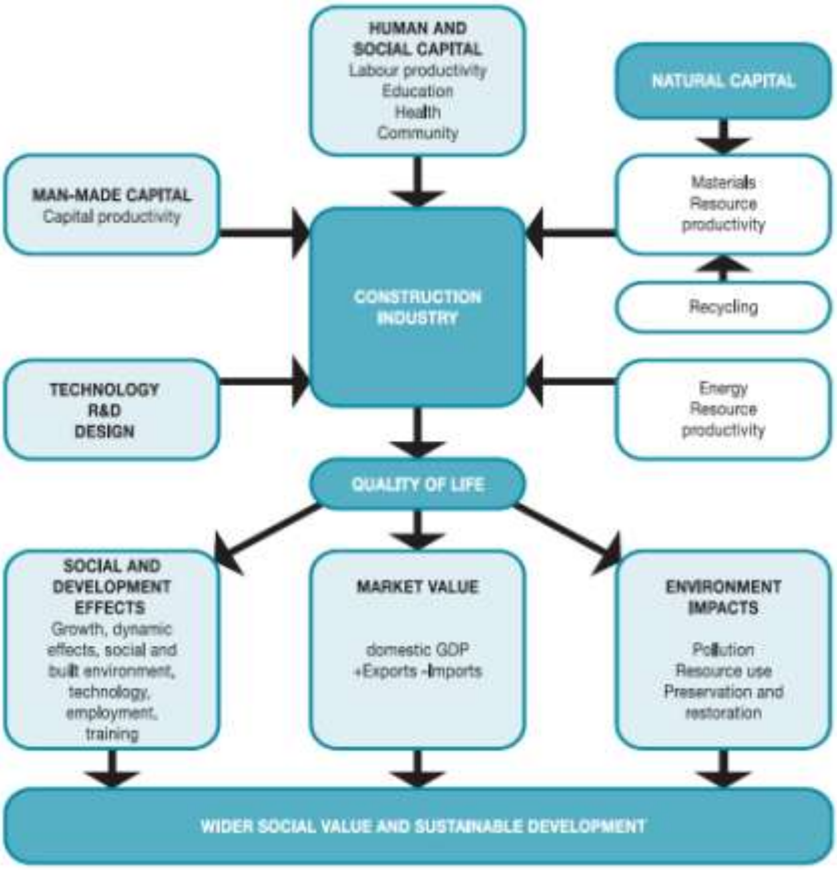

Figure 12. Schema for Sustainable Construction (Source: Pearce, 2003, p.7)

As Porritt (2005) explains,

> "*Back in 2003, after almost a decade of different initiatives in the UK trying to make sense of the concept of sustainable construction... the New Construction Industry and Research and Innovation Strategy asked David Pearce to produce a more authoritative report on the social and economic value of construction. In setting out to answer one deceptively simple question ('exactly what is construction's contribution to sustainable development and the delivery of long term quality of life improvement?'), the research appraised the role of manufactured capital, human capital and social capital, and environmental capital as the critical elements in generating sustainable profits for the construction industry as a whole" (p.116)*

Following this report, Pearce (2006) produced a journal article titled, 'Is the construction sector sustainable? Definitions and Reflections?' where he describes his "asset" based approach.

> "... *wealth is now readily defined as the sum of these four capitals: man-made, human, natural and social... the condition for wealth to accumulate is therefore that savings must exceed depreciation. And accumulated wealth must proceed at a rate faster than population growth, otherwise per-capita stocks of wealth will decline. If per-capita stocks of wealth fall, then capacity to generate rising well-being is correspondingly diminished. This is why rapid population growth remains a very serious threat to sustainable development" (p. 203-204)*

His analysis also highlights the challenges of measuring sustainability sector by sector where the boundaries of accounting are in dispute,

> "*... the construction sector builds houses. Are the emissions from the houses when built to be debited to the [construction] industry or to the household sector? It seems most likely that it should be the latter since the responsibility of the construction ends with the completed act of construction. But some do not see it that way, arguing that the construction industry has a responsibility for what happens to the final product and the way it is used." (p.204)*

In summary, the literature review has examined the history of post-occupancy evaluations and the way knowledge has converged to create a range of knowledge management frameworks which ensure “feedback” is captured throughout each phase of the construction process. Commissioning and energy related issues were then addressed, demonstrating the challenges presented not just by new buildings, but the potential savings through “retro” commissioning the existing estate. To facilitate this process, it has been necessary to develop more sophisticated data analysis techniques using half-hourly data.

From an education perspective, schools are often seen as the central driver for social mobility. In this regard, the building itself has an important role. In order for children to learn, they must feel happy and safe in their environment. Indeed, the more time students spend in school, the better their chances later on. BSF was a programme set up to address these issues. More recently, Sustainable Development has emerged as an overarching policy strategy. In this regard, the 5 Capitals model and the academic discipline of Systems Thinking have been discussed.

In the following chapter, the need for a multi-disciplinary approach using both quantitative and qualitative data will be discussed in relation to a mixed methods methodology.

Chapter 3 Methodology

This chapter deals with the philosophical approach and the methodological reasoning for why a mixed methods design has been used to develop a conceptual framework for a sustainable school. In terms of addressing the 5 objectives however, a more conventional "positivist" mentality was applied. As a result, the totality of the project's research methodology could be described as a concoction of techniques and philosophies used in a "pragmatic" way to extend knowledge through the convergence of both quantitative and qualitative data.

3.1 Introduction

The writing up of this methodology chapter has been challenging for a number of reasons. Significantly, the application of a mixed-methods study has required both quantitative and qualitative research strategies be justified in a logical and complementary fashion within a single project. This has also created a challenge for the way a mixed methods study should be written up, given the conventional orthodoxies associated with both styles of research. Striking a balance between both positivist and constructivist paradigms has therefore called for a more flexible approach.

In the sections which follow, mixed-methods has been identified as the most suitable research strategy to address the project's overarching aim – to develop a conceptual model or framework for Sustainable Schools. However, before advancing such a theoretical proposal, a number of clearly defined objectives have been set out in a typically reductionist fashion. Moreover, by addressing these 5 objectives using a range of multi-disciplinary techniques, the case-study evidence can be infused with the existing knowledge set out in the literature review.

The sequencing of sections within this chapter has also been unusual. Rather than replicating the conventions of existing PhD methodology chapters, a chart which redefines the research problem is presented followed by an interesting anecdote which highlights the limitations of entrenched methodologies. The actual tools and activities are then presented which address the five clearly defined objectives. At this stage it has now been necessary to consider the literature surrounding mixed-methods in terms of developing theory necessary to develop a conceptual model for Sustainable Schools.

Figure 13. Redefining the research problem

2009------------>2010-------------->2011-------------->2012------------>2013	
Building Schools for the Future (2003-2010)	Review of Education Capital – James (2011)
Rhetoric: education/transformation/sustainability	Rhetoric: Fit-for-purpose/value-for-money
Priority given to socio-economic circumstances	Building condition primary determining factor

⇩ ⇩

Original PhD remit	**Updated PhD objectives**
POE of low-energy schools	**Sustainable Schools: Beyond Measure?**
Strategy: Energy /Mixed Methods/ Performance Framework	**Strategy:** Holistic/Inductive/Socio-technical/Mixed Methods
Problems: • No data available • Tensions between stakeholders • Concerns over energy costs • Significant overheating problems identified • Inadequate commissioning	**Problems:** • Difficulty specifying Aims and Objectives • Gathering quantitative and qualitative data • What to analyse and how • Methodology fits around real world constraints • Fusing different models and frameworks together

⇩ ⇩

Connectivity Framework			
Themes & Topics	**8 Doorways**	**3 Pillars**	**5 Capitals**
Physical Perspective - Comfort - Energy performance - Ecology - Layout and Design	1 – Food & Drink 2a – Energy 2b – Water 5a – Buildings 5b – Grounds	Environmental Pillar	Manufactured Capital Natural Capital
Human Perspective - Attainment levels - Teaching expertise - Construction expertise	3 – Travel and Traffic 8 – The Global Dimension	None	Human Capital
Social Perspective - Community Services - Student Behaviour - Incidents of Crime	6 – Inclusion & participation 7 – Local Well-being 8 – Global Dimension	Social Pillar	Social Capital
Economic Perspective - Energy costs - Water costs - Maintenance costs - Total project cost - Local employment	8 – Global Dimension	Economic Pillar	Manufactured Capital Financial Capital

3.2 The Roseto Mystery

In a similar fashion to the way Jonanthon Porritt's 5 Capitals Framework advocates a more "systems" approach to the challenges presented by sustainable development, to capture the essence of "social" capital, Malcolm Gladwell's book, "Outliers" (2008), presents an interesting example which has shaped the background thinking behind this research.

A community from the Italian province of Foggia emigrate to America in the late 19th century. Once they had time to consider their future, they set about recreating their small town from back home called Roseto. They bought land in Pennsylvania and gradually constructed buildings, including a church, school, shops and houses. Indeed to quote Gladwell (2010),

> *"Roseto, Pennsylvania was its own tiny self-sufficient world" (p.5)*

Self-sufficiency conjures up similar ideas to the contemporary notion of sustainability, to persist, to survive, to prosper etc. Interestingly, sometime later once the community was established , a strange phenomena was stumbled upon when a visiting physician (doctor) by the name of Stewart Wolf was invited to give a talk at the local medical society. During informal discussions with local doctors it became apparent how the small town of Rosetto had virtually no incidents of heart disease.

This was particularly significant at the time in 1950s America since heart attacks were the leading cause of death. What their investigations subsequently revealed however was even more surprising for when they examined the medical records, they discovered that virtually no one under fifty five had died of a heart attack or showed any signs of heart disease. In fact they found that men in Roseto over 65 were roughly half as likely to die of heart disease than the average American.

Wolf, perplexed by this phenomenon enlisted sociologist Jon Bruhn to help him investigate the lifestyles of these apparently resilient people. He reports,

> *"There was no suicide, no alcoholism, no drug addiction and very little crime... these people were dying of old age." (p.7)*

Wolf's background in digestion led him to believe this phenomena was connected to diet, but careful inspection of the town's eating habits revealed they were cooking with lard rather than olive oil and that a staggering 41% of their calories were derived from fat.

So lifestyle and diet were now ruled out. Could it be their genetics? To address this third possibility, Wolf tracked down relatives of the Rosetons who were living in other parts of America to see if they too shared the same remarkable good health – they did not.

So perhaps it was local climate that was responsible? But again, analysis of neighbouring towns revealed no such link. Indeed Wolf notes,

> *"For men over 65, the death rates from heart disease in Nazareth and Bangor were three times that found in Rosetto." (p.9)*

To recap, all logical lines of enquiry (lifestyle, genetics, climate) had been checked out without any significant developments. But as Gladwell remarks, when observing the day to day habits of residents, Bruhn and Wolf thought they had discovered the answer.

> *"They looked at how the Rosettons visited each other, stopping to chat in Italian on the street, say, or cooking for one another in their backyards. They learned about the extended family clans that underlay the town's social structures. They saw how many homes had three generations living under one roof, and how much respect grandparents commanded. They went to mass ... and saw the unifying and calming effect of the church. They counted twenty-two separate civic organizations in a town of just under 2000. They picked up on the particular egalitarian ethos of the community, which discouraged the wealthy from flaunting their success and helped the unsuccessful obscure their failures". (p.9)*

Evidently, the conventional methods of investigation were unable to identify or indeed acknowledge how as Gladwell explains,

> *"The Rosetons had created a powerful, protective, social structure... capable of insulating them from the pressures of the modern world" (p.9)*

And when it came for Bruhn and Wolf to publish their findings[5], central to their research was the inherent link between health, well-being and community spirit,

> *"Wolf and Bruhn had to convince the medical establishment to think about health and heart attacks in an entirely new way; they had to get them to realise that they wouldn't be able to understand why someone was healthy if all they did was think about an individual's personal choices or actions in isolation. They had to look beyond the individual. They had to understand the culture he or she was part of, and who their friends and families were, and what town their families came from. They had to appreciate the idea that the values of the world we inhabit and the people we surround ourselves with have a profound effect on who we are". (p.10)*

3.3 Aims and Objectives

For the benefit of the reader, the study's overarching aim has been to create a conceptual model or framework that combines a range of perspectives within a "system" that attempts to simulate the complex and interdependent dynamics of a sustainable school.

To assist in this creative and inductive process, 5 clear objectives have been established.

1. To understand and evaluate the effectiveness of the procurement mechanism.
2. To understand and evaluate the effectiveness of the commissioning activities.
3. To measure energy consumption post-occupancy.
4. To measure occupancy satisfaction post-occupancy.
5. To understand, define and then measure "educational transformation" post-occupancy.

Objectives 1 and 2 are more general and deal with the delivery of phase 1. Objectives 3, 4 and 5 address each school separately. The case-study design has therefore expanded from a single-case (objectives 1 & 2) to a multi-case (objectives 3, 4, 5) design (Yin, 2009).

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[5] - Stout C, Morrow J, Brandt EN, Wolf S. *Study of an Italian-American community in Pennsylvania. Unusually low incidence of death from myocardial infarction*. JAMA 1964; 188: 845
- Bruhn JG, Chandler B, Miller C, et al. *Social aspects of coronary heart disease of two adjacent ethnically different communities*. Am J Public Health 1966; 56: 1493.
- Bruhn JG, Philips BU, Wolf S. Social readjustment and illness patterns: *Comparisons between first, second and third generation Italian-Americans living in the same community*. J Psychosom Res 1972; 16: 387.

3.4 Data Collection Activities

This section describes the various activities and methods which have enabled this study to address all 5 objectives. The intention has been to extract the available “data” from primary and secondary sources, so the findings from the four case studies may contribute to the project’s primary aim.

3.4.1 Procurement

In the absence of utility data at the beginning of the study, the researcher embarked on an extensive literature review covering all aspects of construction. During this period he also spent 1 afternoon per week working at the council offices collecting a variety of data and documentation which related to the first phase of BSF schools in Leicester. BSF documents which helped to inform the research and the subsequent analysis included,

- The Strategy for Change (SfC) report
- Outline Business Case (OBC) report
- Strategic Business Case (SBC) report
- Final Business Case (FBC) report

Over the course of time more evaluation reports were published by the council which contained information about the administrative and logistical challenges presented by the BSF programme as they proceeded beyond the first phase of procurement. Of note was the inclusion of additional funding from the government’s Carbon Calculator of £50/m² to improve energy efficiency across phase 2. It was further confirmed how one of the phase 2 schools was to be a “Zero Carbon” exemplar project, attracting a further £1m from the DCSF.

Having begun to understand how the first phase of schools were delivered, a number of questions relating to sustainability and procurement emerged. This filtered into the conversations and meetings in which the researcher participated in as he began to establish relationships with staff from across the public and private sector domain. To capture their feedback, the researcher documented these conversations and when appropriate conducted semi and unstructured interviews (see appendix; Interview Questions) with individuals from the schools (mostly the

Business Managers), the council (the BSF Project Team) and the practitioners (the main contractor, the design team/the FM provider).

Overtime, as the quantity of anecdotal feedback expanded, so it was possible to refine the project's aim and objectives, consistent with an exploratory inductive approach to research. E-mail correspondence became a crucial part of this process, helping to both foster and maintain a working relationship with participants willing to divulge information about their own observations and experiences. In addition, various members of staff from the council's sustainability division, planning department, and education department were also consulted during the first 18 months of the research as more and more data became available.

It was then possible to synthesize this "feedback" with the relevant literature in order to establish four basic conditions which could either be validated or falsified in order to satisfy objective 1 (procurement).

(i) *The council's output specification prioritised energy efficiency.*

(ii) *Relations and communications between the stakeholder groups were agreeable and effective.*

(iii) *Exposure to different types of project risks were appropriately managed.*

(iv) *Contractual incentives were in place to promote energy efficiency post-occupancy.*

3.4.2 Commissioning

Set within the 'Design and Construction' chapter, the second objective examines the quality of the delivery process in terms of readying the building for occupation. The first activity involved the researcher participating in three "official" walk-through inspections, accompanied by a range of individuals from the public and private sector as well as building experts from the Institute of Energy and Sustainable Development (IESD). A dictaphone was used on all three occasions in order to capture the extended commentary of those in attendance. Transcribing this qualitative data was difficult as there were several people in attendance. Importantly, the exchange of opinions and ideas during these 1hour inspections yielded a rich array of insightful qualitative data.

These inspections were carried out during the summer term of 2010, approximately one year after the buildings were officially opened. At one school (School A), the ‘official’ inspection was cancelled due to issues with staffing availability. By coincidence, this was the school with fewest post-occupancy defects and had previously been visited by the researcher on two early occasions when he was given a guided tour by personnel from the FM provider. It was also interesting to note, that on this particular site, the main contractor had built their own separate out-building which the researcher visited on numerous occasions. It was at this location that meetings and one on one discussions were carried out with practitioners from the private sector.

During this same period, the researcher also conducted semi-structured interviews with the schools’ business managers in order to ascertain how they felt about the BSF programme, the procurement mechanism and finally the actual buildings (see appendix; Interview Questions). These interviews were recorded and later transcribed. At the same time, the researcher had established various contacts with the staff from the FM provider who were also willing to discuss these same issues, although they did not wish to have these conversations recorded. As a result, the researcher took ad-hoc notes at the time which he then later word-processed and clarified. Email correspondence was also used when subsequent questions or issues arose.

Indeed, by the time the schools were entering their second year (September 2010), the council commissioned the BMS manufacturer to carry out four energy audits for each school. Complementing the qualitative data which the researcher had so far extracted from willing participants, four reports were published and made available to the researcher through his contacts at the council. Of note, was the identification of energy and environmental comfort, as the two objectives of this “re-commissioning” activity.

Using the information contained within these audit reports, a more technical appreciation of the building services could be obtained. Moreover, based on the modifications and predicted savings that were contained in these reports, conclusions about the extent to which the original commissioning was inadequate could be made. In addition, as part of an evolving and dynamic research project, the particular date when these energy audits took place has provided a useful time-stamp to examine energy consumption ‘before’ and ‘after’ the re-commissioning.

Specific details about the lines of enquiry and the circumstances of each school have been set out in the analysis sections.

3.4.3 Energy Consumption

Now that each school could be separated more easily, a multi-case study design emerged. Indeed, this third objective was to evaluate energy consumption, which by extension also includes the level of carbon emissions (the environmental perspective). The research has also attempted to validate different sources of utility data, from the manually read figures collected once a month by the FM provider, to the half-hourly electricity data which the utility company, Eon provided.

Table 9. Multiple Case Studies

School	School A	School B	School C	School D
Status	New Build	New Build	New Build	Refurbishment
Contract	Design & Build	BSF-PFI	BSF-PFI	Design & Build
Cost	£15m	£21m	£19m	£14m
Pupils (11 to 16)	1000	1300	1200	900

Moreover, as mentioned above, the re-commissioning in Autumn 2010 has served as a useful time-stamp to examine how the demand for energy has altered following the adjustments to the BMS control settings. This in turn has called for a more detailed examination of the half hourly data to produce daily profile curves. This technique whereby the power in kilowatts (kW) is recorded every 30 minutes highlights when the demand increases and by how much. Normalising the RAW input data by dividing by total floor area (m^2) has been a technique used to allow all four schools to be compared.

In total three software packages have been used. Microsoft Excel was the basic spreadsheet program which contained the raw data files as well as producing the output graphics. In the first 18 months of the project, the researcher received the first year of half-hourly electricity data from the utility company via the council. At the same time, another research student was developing his own predictive model which looked at how patterns of electricity consumption vary in schools across the United Kingdom. Using his bespoke software which was designed to accept multiple data sets, all four schools were compared.

When finally the researcher received the full data set of half-hourly electricity which ranged from June 2009 to January 2012, a commercial program called “Energy Lens” was selected as the preferred software to examine the data. This bolt-on application within Excel provided a range of options which allowed the data to be examined in more detail. For example the raw half hourly (kW) data could be converted into kilowatt hours (kWh) and used to produce weekly, monthly or annual summations. This meant that the monthly meter readings which the FM staff had been collecting could be checked and verified. As the analysis reveals, the data sets were not always the same, and in some cases varied substantially.

Unfortunately the software lacked two functions which could have made the analysis more helpful. Firstly, the software did not allow multiple data sets to be included together in a single output graphic, restricting the ability to compare the buildings. In addition, the software did not allow a building to be normalised based on total floor area. However, the researcher manually edited the input files so the data was converted from kW to W/m² making it easier to compare all four buildings, although it was not possible display all 4 schools in a single graph using Energy Lens.

Ideally the BSF programme should have developed its own suite of POE-Energy software to help support the Local Authority. Linking this software to a national database would then allow benchmarks to be regularly updated. In reality, as the literature review confirms, there needs to be a comprehensive review of existing benchmarks so that targets which exist reflect the type, size and age of a building.

The calendar feature in Energy Lens also allowed specific time segments of the data to be analysed in isolation. This allowed weekdays and weekend consumption to be separated. More importantly, it also allows the analysis to look at consumption before and after the re-commissioning without having to manually modify the input data.

The format of the input (kW – Power) data also meant that 24 hour “power” profiles could be generated which included maximum, average and minimum curves for a particular time period. This was helpful as it illustrates the extent to which energy performance varies. For example, assuming the schools are not used during holiday periods, all three curves would remain close to the standby level. Likewise, weekend consumption should also have a marked reduction compared with weekdays in term time.

Using this program with “sub-metered” data can also help to identify specific locations in the building where energy is used in a wasteful capacity. Moreover, understanding the amount to which an ICT suite, gymnasium or swimming pool contributes to a school’s overall energy consumption is important especially when the BMS system can be “zone” controlled. However, in the absence of reliable half-hourly sub-metered data, opportunities to identify energy savings were limited.

From a seasonal perspective, longitudinal consumption over several months and years demonstrates how demand is influenced by temperature and sunlight. Taking into account school holidays, the summer term for example has a 6 week holiday. Energy consumption is therefore considerably lower. Looking at how Autumn compares with Winter also raises questions about the extent to which a building is used. In Autumn, schools are typically on holiday for only a single week whereas in Winter they break for at least 2 weeks for Christmas. The intensity of consumption may therefore be higher in winter, but the total kilowatt hours (kWh) may still be more in Autumn since the building is in use for longer.

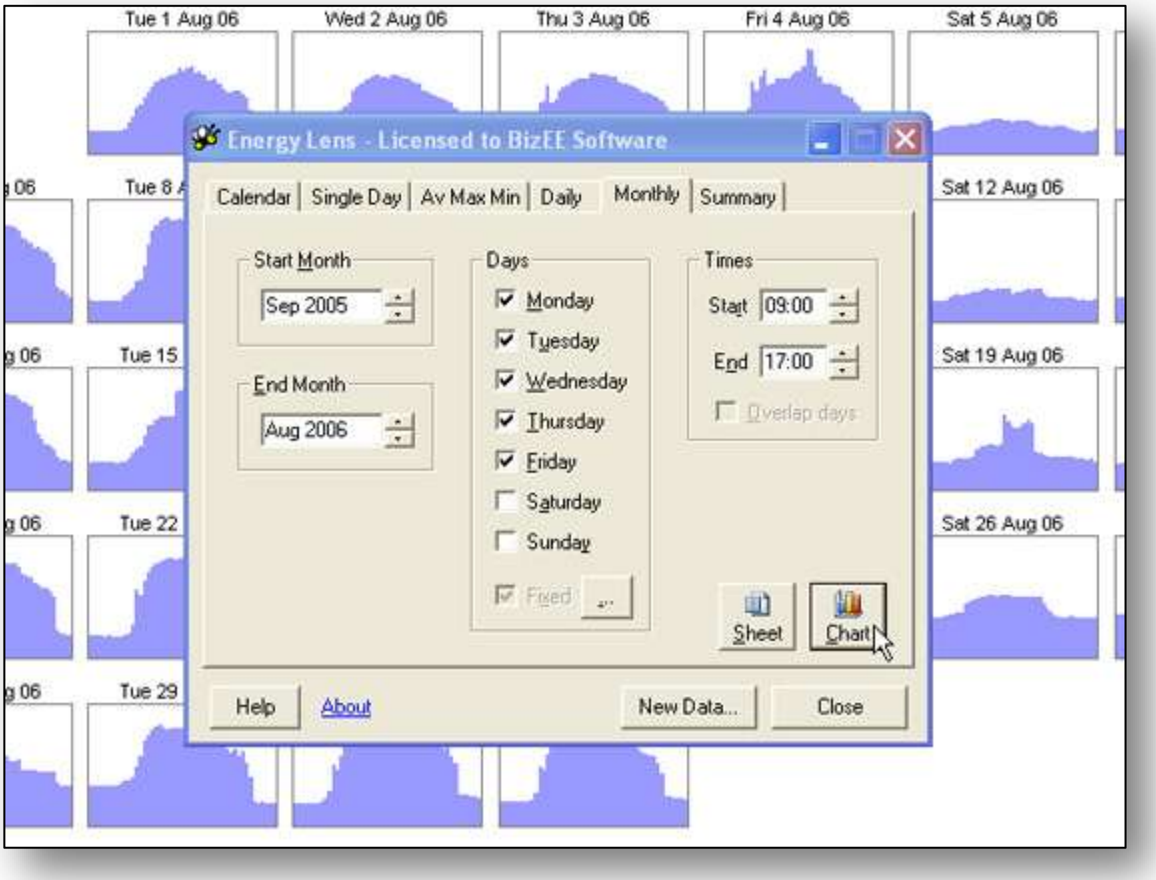

Figure 14. Energy Lens Interface

Crucially, this software was easy to use and allows the user to become familiar with the detailed usage patterns of a school. Furthermore, with schools operating increasingly like community centres from 7am to 10pm, it becomes important that the building services are set up to operate tightly around the schedule of usage. Seasonal adjustments may also be necessary.

The purpose of the energy analysis has been to compare the various data sources, identify instances where energy wastage may have occurred, and finally to track how energy performance has changed over time following the energy audit by Trend, the BMS manufacturer. On this final point, it may be possible to see a gradual rise in consumption if the building is used more frequently by the community. One simple way to track occupancy density or building usage is to examine how water consumption changes over time. If water consumption increases, then it might be reasonable to assume the building's occupancy hours have increased (assuming there have been no leaks etc).

It was hoped that the online database would provide a wealth of reliable high-resolution data which could be accessed through the internet. However, when the researcher examined this data with the available metered data, the data was mostly inconsistent. This also limited the capacity to evaluate different parts of the building without installing separate equipment.

3.4.4 Occupancy Satisfaction

During the first 6 months of the study, the researcher collaborated with an education consultant who had previously been employed as the Head Teacher at School D School during the time when the building was redeveloped and refurbished under the BSF programme. It was now his responsibility to develop a bespoke POE methodology which could be used to evaluate the educational impact across the first phase of schools. His questionnaire included 23 variables using a 1 to 5 rating system. Unfortunately this project was discontinued when he began a new role as Head Teacher at another local secondary school in early 2010. The results for one school (School C) have however been used in this research as an additional source of information.

During the early period when the researcher was carrying out his literature review of POE, the Building Use Study (BUS) methodology was identified as the preferred occupancy survey due to its database and condense layout (see appendix). Indeed, when the researcher continued to look for alternative questionnaires it became clear that the BUS methodology and questionnaire offered many advantages over a bespoke solution which the council's education consultant had previously been working to develop.

Before the BUS methodology could be used however, the researcher had to seek formal permission and set up a license agreement which can be viewed in Appendix B. Indeed, with various academic publications already using this methodology, its use for the present research offered the required levels of quality and reliability.

Moreover, as part of the study's "pragmatic" response to the inadequacies of the BSF guidance literature on post-occupancy evaluation, the decision to adopt a 'tried and tested' staff satisfaction methodology was also seen to enhance the project's legitimacy as a serious piece of research.

BUS Methodology (2010)[6]

The BUS methodology has now been in development since 1985 when it was originally 16 pages. Since then it has been reduced to only 3 pages and takes approximately 10 minutes to complete. A full version has been inserted into the appendix section. Quoting verbatim from the supporting literature (shaded grey), the sections below summarise the many benefits this methodology provides.

"The BUS analysis method is a quick and thorough but not simplistic way of obtaining professional-level feedback data on building performance, primarily from the occupants. It may be used by itself, or with other techniques as part of a wider post-occupancy evaluation.

By professional we mean:

- *Useful by advanced design practices and research organizations for obtaining diagnostics on building performance.*
- *Passes examination by Ethical Standards Committees.*
- *Statistically rigorous, to satisfy high standards of data reporting and analysis.*
- *Interesting and easy to understand for non-specialists.*
- *Incorporating benchmarks which are empirically sound (that is, based on results from real buildings, not simulations, theories or guesswork).*
- *Cross-disciplinary, so that findings are equally useful for designers, managers, researchers, developers and occupiers.*

Source: Building Use Survey (2010)

In terms of the logistics associated with administering the questionnaire, the methodology explains,

[6] http://www.usablebuildings.co.uk/BUSMethodology.pdf

We find the questionnaire to be a good compromise in achieving our objectives. It is/gives,

- *Easy to understand for most building users.*
- *Quick to fill in.*
- *Rapid to administer (in and out of the building the same day).*
- *Not a threat to anybody (questions can be vetoed).*
- *Sufficient information for different viewpoints (e.g. architecture, building services, Facilities Management).*
- *A balance between qualitative and quantitative data.*
- *Underpinned by a database, so data can be further interrogated if required.*

Source: Building Use Survey (2010)

The main results are then presented as Appendix A – up to 50 pages of numerical quantitative data, and Appendix B – Comments from respondents. In total 65 variables are contained within the questionnaire which includes the follow list of conditions,

- *Background information about age, sex, time in the building, time at desk, time at VDU, workgroup size, window seats, and other basic information about the sample and the respondents.*
- *Ratings and feedback for design, needs, image, cleaning, storage, meeting facilities.*
- *Response times for key variables.*
- *Perceived productivity.*
- *Perceived health.*
- *Thermal comfort.*
- *Ventilation.*
- *Lighting, including glare.*
- *Noise, including interruptions.*
- *Furniture and space in the building.*
- *Other workplace performance variables including e.g. perceived control.*

Source: Building Use Survey (2010)

The methodology was also developed to support a range of individuals, allowing;

1. *Designers, especially architects and engineers, to assess how well buildings work as part of briefing, design, post-occupancy analysis and strategic thinking about the future.*
2. *Occupiers, to see whether their buildings give value for money, especially with respect to the staff's needs and perceptions.*
3. *Managers, to help improve services to occupiers and users.*
4. *Developers, to extend and improve their products and services.*
5. *Consultants, to increase their knowledge of how buildings work.*
6. *Researchers, to extend their data sources and knowledge base.* ***Source: BUS (2010)***

More generally, the purpose of this research has been to consider, not just the four case study schools, but to highlight the underlying requirements for a national schools POE methodology. Indeed, by adapting the BUS system exclusively for schools, a bespoke methodology could be used to create a dedicated “occupancy satisfaction” database nationwide. This in turn may help to support a more stable approach to the way government maintains and renews the country’s estate of schools, especially when there is a change in administration following an election as was the case in 2010.

Specific details about the way each school completed this survey have been included in the analysis chapter.

Finally, the BUS methodology would ordinarily cost £1000 per building, but was available for free for ‘supervised postgraduate students’. Arup and Building Use Studies were the two organizations who maintain and administer this methodology (see license in appendix).

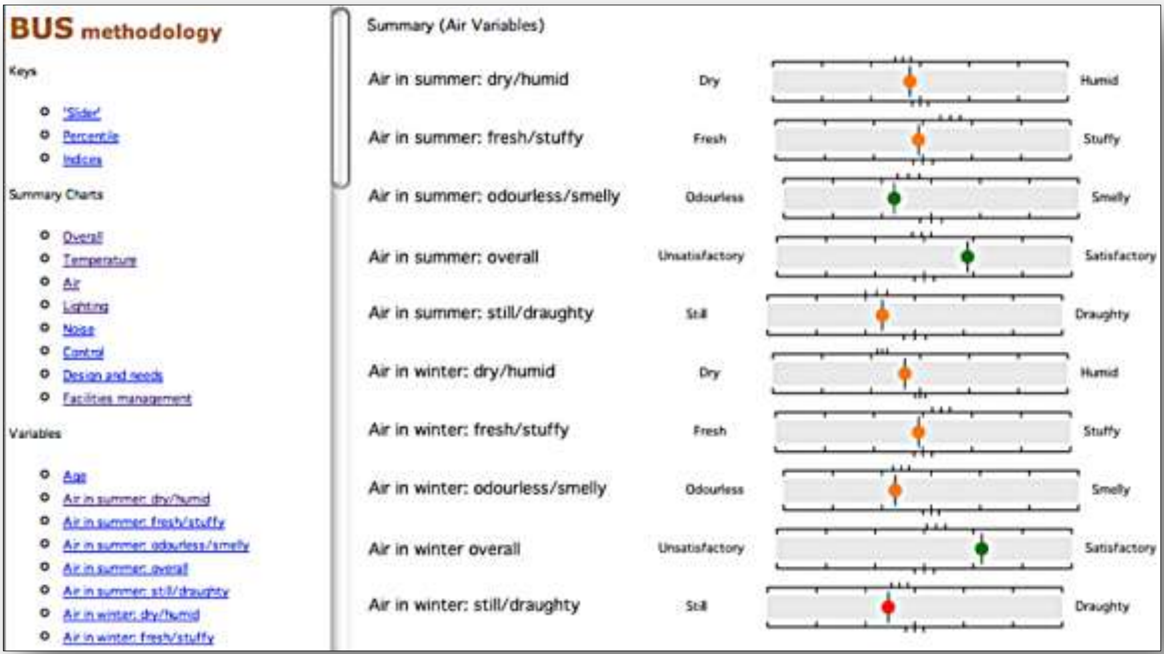

Figure 15. Web Browser Results (Source: 2010 BUS guidance documentation)

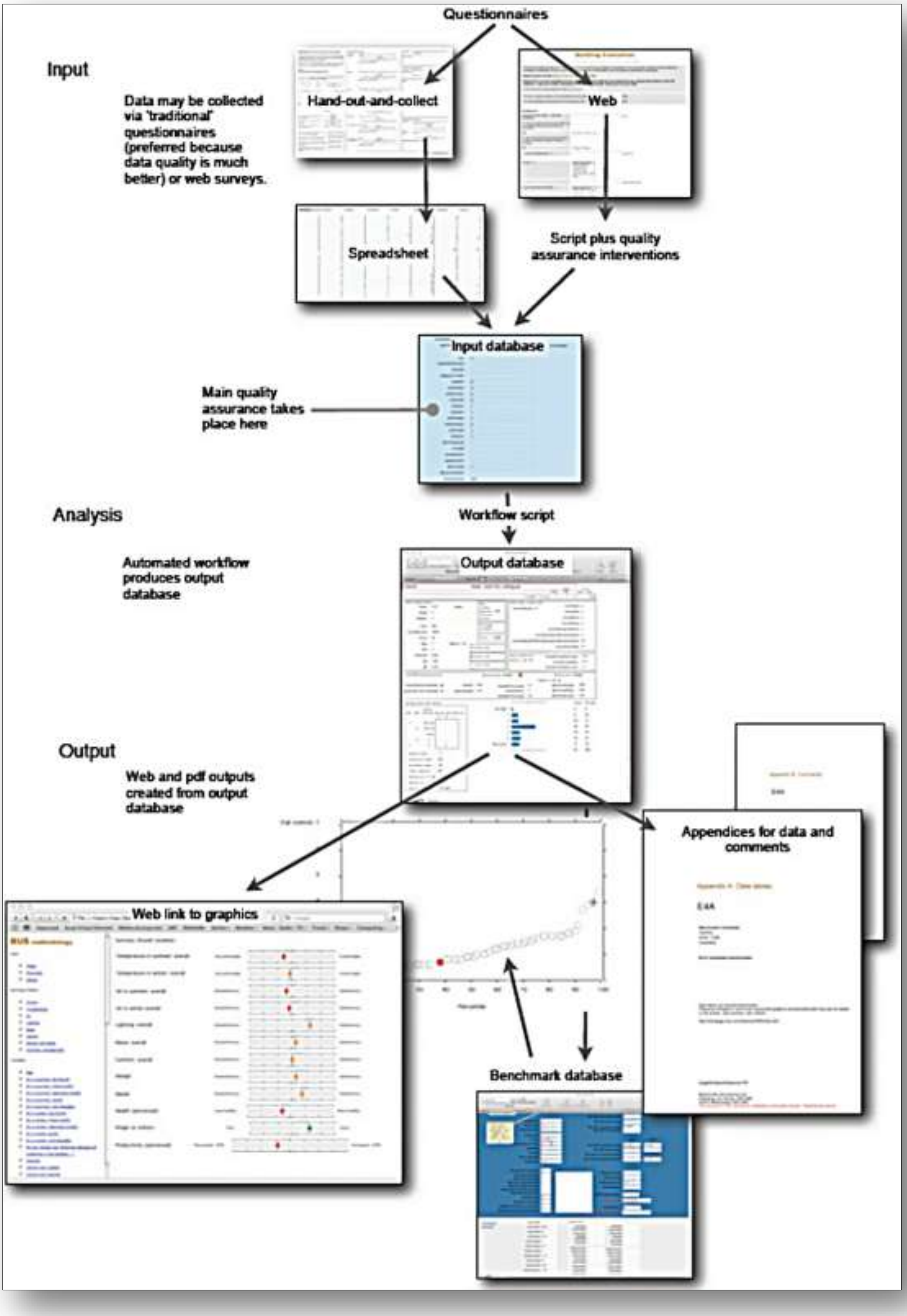

Figure 16. BUS Methodology (Source: 2010 BUS guidance documentation)

3.4.5 Educational Transformation

One of the main ambitions of the BSF programme was to identify schools with high levels of social deprivation so the advantages of infrastructure renewal could have the maximum effect. However, the House of Commons Report (2007) was critical about the ambiguous use of the term "educational transformation" in this regard. Developing a conceptual model which identifies the fundamental elements of a sustainable school was seen to be 'one' way to reconcile the uncertainties and competing elements which the contemporary debate was unable to clarify. From an educational perspective, the present research has chosen to examine each school over a 10 year period, starting in 2002 and finishing in 2012.

To begin with, a review of the Ofsted reports dating back to the year 2000 were downloaded from the internet and examined. Early reports were up to 70 pages in length with a strong focus on subject and departmental performance. A new focus on child welfare following the ECM (2003) report appears to have influenced the way in which Ofsted now carries out and documents their inspections. From 2006 onwards, inspection reports were no more than 15 pages long, divided between 2 key sections,

1. Overall effectiveness: How good is the school?
2. The school's capacity for sustained improvement.

The researcher then looked at each schools' website and prospectus in order to extract as much relevant information as possible. Wider internet searches also uncovered a range of articles in the local and national press about the way the BSF programme was developing, helping to demonstrate why the present research was both relevant and contemporary.

To anchor the research using conventionally quantitative data, the researcher collected a range of statistical data over a 10 year period (2002-2012) which the council provided in addition to information extracted from the government's national website (www.education.gov.uk).

The four main sources of data include,

1. GCSE results, specifically the percentage (%) of students achieving 5 A* to C grades.
2. Attendance/Absence (%) data
3. Special Educational Needs (SEN) (%) data.
4. Free School Meals (FSM) (%) data.

Sources 1 and 2 were obviously more important in terms of numerically tracking performance and behaviour, with sources 3 and 4 providing the 'control' or 'context' variables which help to shed light on the local socio-economic conditions facing each school.

The third aspect of the analysis utilised the parental survey data which Ofsted collected in three out of the four schools on two separate occasions (2002/3 and again in 2009/10). By looking at both questionnaires it was possible to identify 8 "common" questions. Specific details of this methodology have been presented in the analysis section. More generally, parental "engagement" (i.e. parental participation in their child's education) is a central part of developing trust and solidarity within communities (aka "social" capital). It has therefore been interesting to measure how parental attitudes may have changed following the completion and occupation of the four new school buildings.

The fourth and final aspect of the "educational transformation" methodology has incorporated the findings from objective 4 – staff occupancy satisfaction. To provide a comparative summary graphic, the researcher created his own bespoke "spider" diagram that includes all four schools in addition to the BUS database average which is based on scores collected from 400 previous buildings.

In summary, "Educational Transformation" has been broken down into 4 sections,

(i) 10 years of Ofsted Reports (qualitative – attainment...)
(ii) 10 years of educational statistics (quantitative – transformation...)
(iii) Parental survey using Ofsted data (quantitative – engagement...)
(iv) Staff "occupancy" survey (quantitative and qualitative – productivity...)

In the following section, a detailed discussion about the way research is carried out has been considered in context with the current project's desire to include both quantitative and qualitative data as part of a mixed-methods study.

Furthermore, given the multi-disciplinary nature of Sustainable Development, the current research may be useful to guide future projects which attempt to combine a range of socio-technical elements into a single project.

3.5 Types of Evaluations

Robson (2002) distinguishes between “flexible” and “fixed” designs where the research activities may typically operate within an open or closed system respectively. For this study, a “flexible” design has been adopted. Interestingly, Robson (2002) links flexible designs with qualitative and mixed methods research,

> “*The two labels, ‘qualitative’ and ‘flexible’, capture important features of such designs. They typically make substantial use of methods which result in qualitative data (in many cases in the form of words). They are also flexible in the sense that much less pre-specification takes place and the design evolves, develops and (to use a term popular with their advocates) ‘unfolds’ as the research proceeds... Indeed one of the arguments in this text is that there can be considerable advantage in using mixed-method designs, that is, designs which make use of two or more methods, and which may yield quantitative and qualitative data” (p. 5)*

Pertinent insofar as the current study is an evaluation of the BSF programme as well as the “post-occupancy” performance of the four phase one case study schools in Leicester, Robson (2002) also makes a distinction between “formative” evaluations, ‘*intended to help in the development of the programme, innovation or whatever is the focus of the situation’*, and “summative” evaluations which ‘*concentrate on assessing the effects and effectiveness of the programme... not simply the extent to which stated goals are achieved, but all the consequences that can be detected’ (p. 226).* In addition, *“*Process” and “outcome” evaluations were described as follows,

> “*The traditional view of evaluation restricted the questions asked to those concerning outcome. The task was seen as measuring how far a programme, practice, innovation, intervention or policy met its objectives or goals ... Process evaluation is concerned with answering a ‘how?’ or ‘what is going on?’ question. It concerns the systematic observation and study of what actually occurs in the programme... Process evaluation provides a useful complement to outcome evaluation of either the systems analysis or behavioural objectives variety” (p.227)*

Robson (2002) discusses the role "theory" plays in a research project explaining how 'theory-in-use' or 'tacit theory' can develop during the course of the field work activities. He further highlights how theory "generation" occurs through the systematic analysis of new data. Moreover, he explains that a theory "expressed in diagrammatic form, is sometimes referred to as a *conceptual framework"* (p.63). However, he was also mindful of the more general definition when he explains,

> *"Theories can range from formal large-scale systems developed in academic disciplines to informal hunches or speculations from laypersons, practitioners or participants in the research" (p.61)*

To add an element of validation or reliability to this process, Robson (2002) explains how "*you can build replication into your design by having, say, a set of linked case studies which share important characteristics" (p. 63).*

3.6 Case Study

As the original PhD remit sets out on the final page of the appendix, the research was already pre-defined in terms of the case-studies to be examined.

Yin (1981) highlights how the case study approach should be viewed not as a method, but as a "research strategy". Such a strategy can include a range of data types as listed below, although qualitative methods tend to be more common.

1. Documents (e.g. letters, agendas, newspaper articles)
2. Archival records (e.g. organisational records, survey data)
3. Interviews (e.g. semi-structured, focused, open ended)
4. Direct observation (unobtrusive observation during field research)
5. Participant observation (researcher becomes an active participant when observing)
6. Physical artefacts (e.g. tools, instruments or other physical evidence obtained).

Furthermore, Yin (2003) suggests how a case study represents '*an empirical enquiry that in explanatory, exploratory and descriptive contexts, can contribute to knowledge of individual,* *group, social, political and related phenomena'*. To clarify these terms Onwuegbuzie and Leech (2006, p.479) provide the following definitions.

- **Explanation** was described as '*developing theory for the purpose of elucidating [making something clearer] the relationship among concepts of phenomena and determining reasons for occurrences of events'.*
- **Exploration** was described as '*primarily inductive, used to explore a concept, construct, phenomenon, or situation in order to develop tentative hypotheses or generalisations'*.
- **Description** was said to involve the identification of *'antecedents, nature and etiology [study of causation or origination] of phenomenon'.*

In terms of the way the current research was devised, the initial evaluation of the procurement and commissioning activities involved a more qualitative analysis using the sources of evidence which Yin refers to above. As such, the analysis was not comparative and developed more along a single case-study design. When the new buildings were officially opened and occupied from September 2009 however, at which point the PhD project began, the post-occupancy performance of the four phase one schools inevitably led to a more comparative and multiple case study evaluation developing. As such, the research design operated along a normal chronologically time line, starting with procurement and commissioning "processes", eventually finishing off with a more social educational perspective.

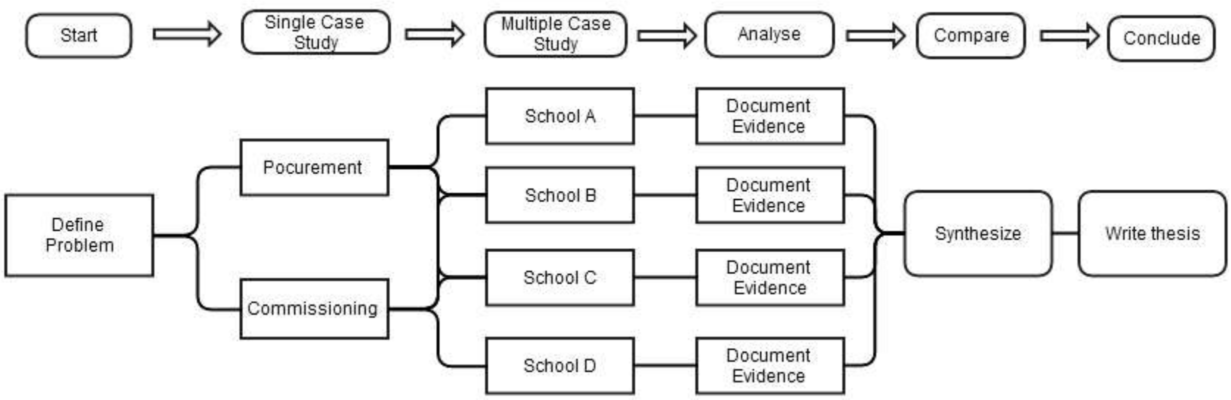

Figure 17. Case Study Approach

More generally, Yin (2003) explains how fieldwork activities may commence prior to the identification of specific research questions or objectives, although a theoretical understanding of the problem is helpful at this stage. At the same time, he also acknowledges the problems associated with individual bias when observing a particular situation. Moreover, the limitations of a single case-design prevent generalisations being made across the population. Under the circumstances, documenting the experiences of Leicester's phase one programme may provide a range of helpful insights for the subsequent 12 schools to be built, as well as highlighting the challenges local governments face when procuring large scale infrastructure programmes via PFI.

Furthermore, Yin (2003), explains how a single case study approach is applicable when the phenomena under investigation is either critical, unique or indeed revelatory. Evidently, the BSF procurement mechanism which involved the creation of a public-private enterprise, namely the Local Education Partnership (LEP), was untested and therefore critical and/or unique. By the same token, the post-occupancy evaluation which employed a multiple case study design included both quantitative and qualitative data as part of a mixed methods design with multiple embedded units of analysis (energy, attainment, occupancy satisfaction etc).

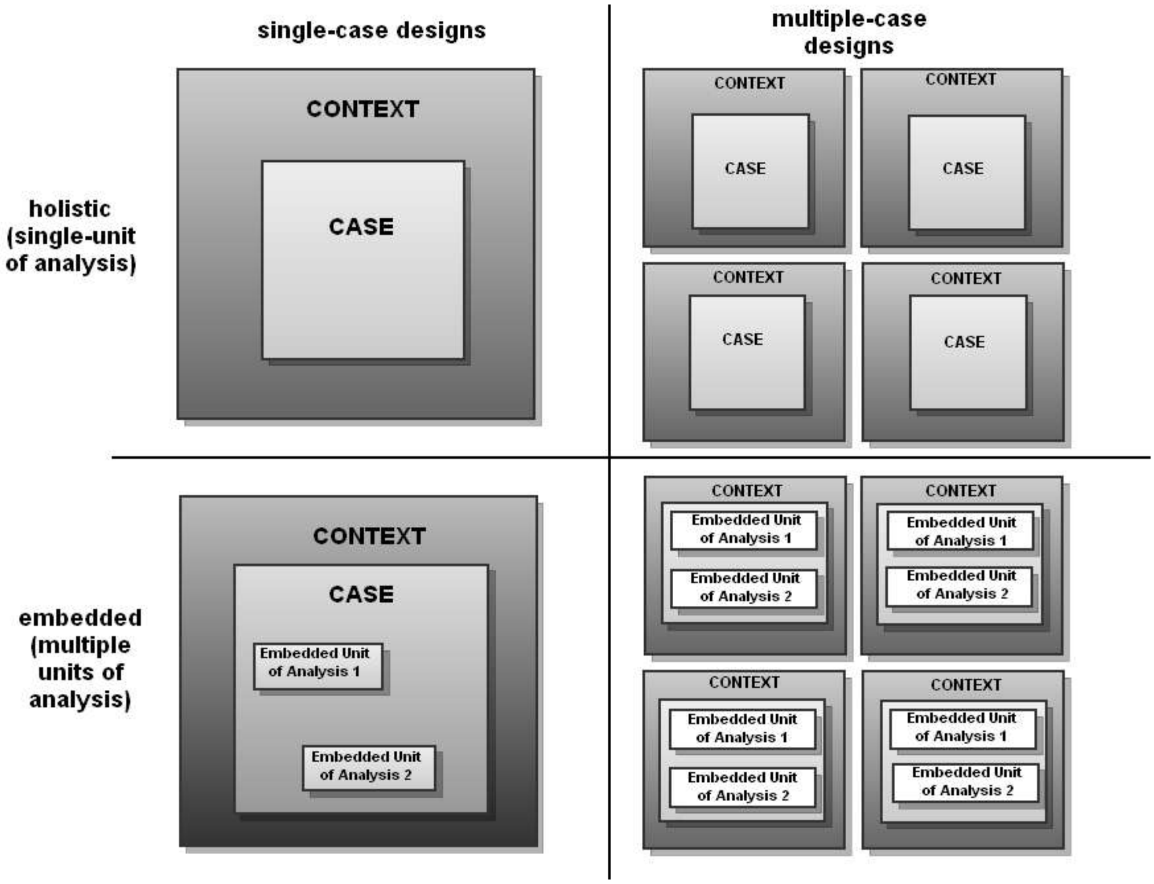

Figure 18. Case Study Types (Yin, 2009, p.46)

As this diagram helps to illustrate, the initial procurement and commissioning elements of the programme were indicative of a single-case holistic design, where the "context" was BSF, and the "case" was "phase one". The post-occupancy evaluation, including the analysis of "educational transformation" by contrast was more complex. Each "context" relates to the individual schools, and the "embedded units of analysis" relate to the energy, attainment, behaviour, parental engagement and staff satisfaction – objectives 3 to 5.

However, the number of case-studies which should be included in a single project and the extent to which each case should be investigated remains uncertain. Miles and Huberman (1994) indicate that more than 15 cases may become unmanageable, whilst Eisenhardt (1989) suggests that 'theoretical saturation' alone should determine the number of cases. In this particular study, the number and selection of cases was an aspect of the design which the researcher did not control.

Indeed, whilst it was difficult achieving the level of data saturation originally anticipated, the study's more expansive and exploratory approach sought to examine and measure the various aspects associated with Sustainable Development. This in turn led to a more cursory approach to the way each individual activity was researched. As a result, the current study's methodology borrows from both sides of the quantitative-qualitative divide as table 10 on the following page helps to summarize.

Table 10. Qualitative Vs Quantitative Approaches

Qualitative	Quantitative
Assumptions	
Reality socially constructed	Facts and data have an objective reality
Variables complex and interwoven; difficult to measure	Variables can be measured and identified
Events viewed from informant's perspective	Events viewed from outsider's perspective
Dynamic quality to life	Static reality to life
Purpose	
Interpretation	Prediction
Contextualisation	Generalisation
Understanding the perspectives of others	Casual explanation
Method	
Data collection using participant observation, unstructured interviews	Testing and measuring
Concludes with hypothesis and grounded theory	Commences with hypothesis and theory
Emergence and portrayal	Manipulation and control
Inductive and naturalistic	Deductive and experimental
Data analysis by themes from informants descriptions	Statistical analysis
Descriptive write-up	Abstract impersonal write-up
Role of researcher	
Researcher as instrument	Researcher applies formal instruments
Personal involvement	Detachment
Empathetic understanding	Objective

Source: Burns, 2000, p.391 (as quoted by Coley, 2008, p.52)

On the following page, the researcher identified an exhaustive summary of the various paradigms which exist today. Moreover, by taking time to examine and digest the contents of this table, it is possible to appreciate the complexity surrounding the different approaches and mindsets which govern the way different research activities are carried out.

In this particular study, the challenge has been to justify the decisions taken in relation to the fieldwork activities as well as the various types of secondary data to be included as part of a holistic multi-disciplinary investigation.

Table 11. Paradigm Contrast Table

Dimension of Contrast	Constructivism	Transformative	Pragmatism	Post-positivism	Positivism
Principal Philosophy	- Reality is viewed socially and societally embedded and existing within the mind - There is no objective knowledge - Knowledge is constructed jointly with researcher and researched via consensus	- Primarily used to address issues for oppressed groups, inequality and social injustice using culturally competent mixed methods strategies - Recognises that realities are constructed and shaped by social, political, cultural, economic, and racial/ethnic values	- Agrees with positivist and post-positivist stance on the existence of external reality - Does not believe that truth regarding reality can actually be determined - Unsure that any one explanation is better than any other - There is no single best scientific method that can be indisputable knowledge	- Considers that research is influenced by the theoretical framework employed - Questions the ability to prove a theory or causal proposition - A number of theories can account for a body of evidence - Recognises the value-ladenness of facts and the potential influence the researcher can have	- Views truths as absolute and values the original and unique aspects of scientific research i.e. realistic descriptions - Truthful depictions, studies with clear aims, objectives and properly measured outcomes
Major Characteristics	- Exploration of the way people interpret and make sense of their experiences - Identification of how the contexts of events and situations impact on constructed understanding	- Qualitative dimension is needed to gather community perspectives - Quantitative dimension can demonstrate outcomes that have credibility for community members - Seen as a mechanism for addressing the complexities of research in culturally complex settings	- Regard knowledge as being based on practical outcomes and “what works” - Knowledge is provisional in that what is regarded as truth today may not be so in the future - Rejection of immovable distinctions such as facts vs values, objectivism vs subjectivism, rationalism vs empiricism - Seeking absolute truth is not an objective	- A paradigm which is seen to replace the more extreme facets of positivism - Seen as the intellectual heir to positivism - Still bound to the quantitative vision of science - Acceptance of the view that researchers of any leaning, QUAL or QUAN, are prone to constructing their own view of social reality	- Knowledge is viewed as being able to be deduced from careful hypothesis design - Domain features are dominated by regularity - Believe that everything is caused by something - Statistical analysis to deemed to be able to discover facts
Methods	- Qualitative	- Both Qualitative and Quantitative. - Community of participants involved in methods decisions	- Both qualitative and Quantitative - Researchers answer questions using best methods	- Primarily quantitative	- Quantitative
Logic	- Inductive: observation is used to build theory	- Inductive and deductive	- Inductive and deductive	- Deductive	- Deductive: previously formed theory is tested
Epistemology	- Subjective point of view - Sense of reality constructed with participants.	- Objectivity and interaction with participants valued by researchers	- Objective and subjective points of view sought, depending on stage of research cycle	- Modified dualism (either/or choices)	- Objective point of view
Axiology	- Value-laden inquiry	- Value inquiry	- Value important in interpreting results	- Value in inquiry but their influence may be controlled	- Value-free inquiry
Ontology	- Multiple constructed realities	- Diverse viewpoints regarding social realities - Explanations that promote social justice	- Diverse viewpoints accommodated. - Best explanations within personal value systems	- Critical realism - External reality is understood perfectly and probabilistically	- Naive realism - Objective external reality that can be comprehended
Causal Linkages	- All entities are simultaneously shaping each other - Impossible to distinguish between causes and effects	- Causal relationships may exist but these need to be understood within the framework of the research	- Causal relationships may exist but these are transitory and hard to identify	- Causal identifiable in a probabilistic sense that change as more predictors are identified	- Real causes occur before or simultaneously with effects
Generalisation	- Believe that only time and context bound ideographic statements are possible - Emphasises the importance of transferability of results from one setting to another	- Emphasises ideographic statements - Willing to link results from a specific study, often a single case study and applies that to broader issues.	- Emphasises ideographic statements but not to the exclusion of other view points - Frequently carried out as a single case study which can become an exemplar for others	- Accepts measures that are observed from a relatively large sample to give a general outlook. - Willing to recognise caveats	- Believe that time and context free generalisations are possible - Total belief and utter confidence that the numbers speak for themselves - Extrapolation of findings to assume representation of a much larger population are typical

Familiarising oneself with the intricacies and details of table 11 has been vitally important when thinking pre-emptively and retrospectively about the current research project's methodology. In fact, this table represents the culmination of thinking around this topic of knowledge creation as demonstrated by the range of peer-reviewed publications[7] cited below. Indeed, from the many academic essays which debate this topic, the recent popularity of "mixed methods" has been instrumental in developing what some academics (Armitage, 2007) refer to as the "third way" – that is, the integration of quantitative and qualitative data in a single study.

3.7 Understanding Mixed Methods

'Sustainable Schools, beyond measure?' was a question posed by the current study in an effort to clarify how Sustainable Development can be woven into the physical and social fabric of a school. Conceptualising BSF as a "system" which can deliver the manufactured side of this strategy has also incorporated the remaining themes set out within the 5 Capitals Framework, namely the human, social, environmental, and financial elements. Indeed, by addressing each objective, a multi-disciplinary approach has evolved.

One of the project's more enigmatic characteristics, as prefaced in the original PhD remit (see final page of Appendix B) includes "mixed-methods" as a research strategy. Not to be confused with a multi-methods design which Hesse-Biber (2010) describes as,

> "... *two or more qualitative methods in a single research study (such as in-depth interviewing and participant observation) or by using two or more quantitative methods (such as a survey and experiment) in a single research study..." (p.3),*

Mixed methods has since been defined by Johnson & Onwuegbuzie (2004) as,

> *"... a class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study" (p.17)*

[7] Cherryholmes (1992); Denscombe (2007); Durkheim (1983); Cook and Campbell (1979), Denzin & Lincoln (2005); Grbich (2007); Guba & Lincoln (1994, 2005); Howe (1998); Lincoln & Guba (1985, 2000); Mertens (2003, 2007); Miles & Huberman (1994); Shadish *et al.,* (2002), Tashakkori & Teddlie (1998); Teddlie & Tashakkori (2003); Teddlie & Tashakkori (2009); Weber (1949)

Yin (2009), speaking from a case-study perspective, continues to justify this style of enquiry,

> *"... mixed methods research can permit investigators to address more complicated research questions and collect a richer and stronger array of evidence than can be accomplished by any single method alone" (Yin, 2009, p.63)*

Furthermore, he continues to explain how,

> "... *embedded case studies rely on more holistic data collection strategies for studying the main case but then call upon surveys or other more quantitative techniques to collect data about the embedded unit(s) of analysis. In this situation, other research methods are embedded within your case study" (Yin, 2009, p.63)*

Commentators (Rocco *et al.,* 2003) of Mixed Methods have frequently attached "pragmatism" (see table 11 for more information) as the most appropriate paradigm, suggesting how,

> "*... the exploratory inductive process that begins with empirical evidence of the particular ... proceeds to a level of abstracting, theorizing, generalizing and the confirmatory deductive process of hypothesis testing" (p.22)*

Figure 19 helps to illustrate this dynamic, as the theoretical "big picture" sharpens in clarity to initiate the more focused propositions and hypotheses.

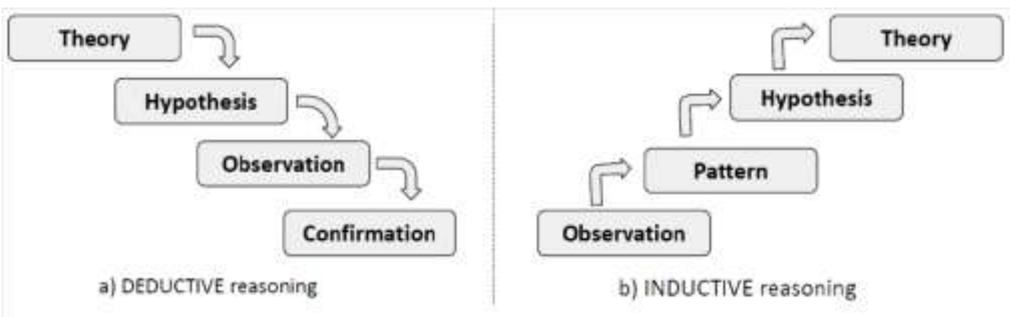

Figure 19. Inductive and deductive Reasoning (Trochim and Donnely, 2007)

More recently, with the creation of *The Journal of Mixed Methods Research* in 2007 (published by Sage, see; mmr.sagepub.com), Hesse-Biber (2010) explains how,

> “*External pressures to combine methods are coming from governmental and private funding agencies, evaluators and other stakeholders who increasingly want researchers to utilise mixed methods to explore social policy issues” (p. 1)*

From a methodological perspective however, Rocco *et al.,* (2003, p.23) argue that by adopting a mixed methods design, the inherent flaws associated with both quantitative and qualitative designs are minimised.

- *Quantitative research tends to be less helpful through its oversimplification of causal relationships, and,*
- *Qualitative research tends to be less helpful through its subjective selectivity in reporting.*

The appropriate deployment of mixed-methods can therefore improve the reliability of research findings. Moreover, it was first noted by quantitative researchers Campbell and Fiske (1959) that mixed methods was a helpful technique to measure a psychological trait. Their call for “multiple methods” was to make sure the variance was linked to the observed trait and not the method. This later expanded into what Denzin (1978) called “triangulation”. More recently, Denzin (1989) explains that,

> “... *by combining multiple observers, theories, methods and data sources, [researchers] can hope to overcome the intrinsic bias that comes from single-methods, single observer, and single theory studies” (p.307)*

Greene *et al.,* (1989) have since identified five reasons to promote the adoption of mixed-methods – Triangulation, Complementarity, Development, Initiation and Expansion. Of greatest relevance to the current study was *complementarity* and *development* which Hesse-Biber defines as follows,

> “*Complementarity allows the researcher to gain a fuller understanding of the research problem and/or to clarify a given research result. This is accomplished by utilising both quantitative and qualitative data and not just the numerical or narrative explanation alone to understand the social story in its entirety.” (p.4)*

“Development: Mixed methods often aid in the development of a research project by creating a synergistic effect, whereby the results from one method... help develop or inform the other method” (p.5)

In this regard, the sequencing of activities becomes a factor for consideration. In the present study for example, the energy analysis was influenced by the date when the re-commissioning of the BMS systems took place. More generally, one of the problems for a single researcher embarking on a mixed methods research project is the management of multiple activities and stakeholders. Further challenges arise when the research objectives are not clearly defined from the outset. Indeed, as the POE literature has already confirmed, academics operating from the peripheries are limited by circumstance. With hindsight, formal introductions with key stakeholders would be advisable when engaging in this type of research activity.

Looking now at the components of a paradigm as set out on the left hand column of table 11, Rocco *et al.,* (2003) explain how ontology relates to an individual’s perception of reality, i.e. their philosophy or “worldview”. Similarly, epistemology refers to the question about “what” can be known or discovered depending on the methodology to be adopted. And finally, axiology considers what is ethically “right” or “wrong” when determining the most appropriate course of action. The following extract articulates both sides of the positivist-constructionist continuum.

“One purist perspective is articulated by the positivists (and post-positivist). For them reality may be, at least to some degree objectively known, and some degree of causal linkage may be legitimately claimed. This is possible when they strive to keep their values out of their research and when they employ primarily deductive logic and quantitative methods of research. The second purist perspective is associated with the constructivists or interpretivists. They believe reality to be socially constructed and only knowable from multiple subjective points of view. The knower and the known are seen as inseparable. Inductive logic and qualitative methods are generally employed with the goal of understanding a particular phenomenon within its social context.” (Rocco et al., 2003 p.21)

By contrast,

> *"The pragmatists position calls for using whatever philosophical and/or methodological approach works for the particular research problem.... mixing may occur in a particular study if the researcher decides it will help make the data collection and analysis more accurate... [thus] research is stronger when it mixes paradigms because a fuller understanding of human phenomena is gained"* (Rocco *et al.,* 2003 p. 21)

However, as shall be discussed in the next section, "integrating" paradigms in an effort to promote mixed-methods identifies various methodological problems, making research more complicated.

3.8 Methodological Complexities and Practical Limitations

As figure 13 'Redefining the research problem' (p.89) makes clear, the development of the research problem was obstructed by a range of circumstantial issues which resulted in the development of a more holistic and flexible research strategy. At the same time, experts in the field have expressed caution when selecting a research question which is arguably too general (Yin, 2009). Indeed, the capacity for the novice researcher to acquire the necessary skills and experiences to carry out a mixed-methods study has become an important methodological issue concerning the present research. Indeed, as Rocco *et al.,* (2003) conclude,

> "*Many research questions and topics of interest lend themselves to mixed methods approaches. Yet, current research training typically lacks the appropriate use of mixed methods in all but the most rudimentary ways (e.g. triangulation)." (p.27)*

Bazeley's (2004) account of the issues facing mixed methods criticises the way *triangulation 'has been greatly misused in relation to both purpose and design' (p.3).*

> "*The original model of triangulation assumes a single reality and ignores the symbolic interactionist foundation of much qualitative work which proposes that different methods (or researchers or participants) will necessarily view or construe the object of the research in different ways... While the use of parallel methods may not, therefore, provide*

corroborative evidence, they may well add depth or breadth to a study and perhaps even hold the key to understanding the processes which are occurring" (p.4)

As such the research methodology has taken a more exploratory inductive approach by adopting methods and techniques which 'complement' one another in order to develop new perspectives. Bryman (2007) for example suggests,

"*The key issue is whether in a mixed methods project, the end product is more than the sum of the individual quantitative and qualitative parts." (p.8)*

He also explains how researchers may simply experience practical problems in the field, which by extension limit their ability to integrate their findings, noting,

"*... the Quantitative and Qualitative components of a MM study may get out of phase with each other, because of their different needs and rhythms... " (p.15)*

Bryman (2007) further highlights the barriers facing mixed methods, when he explains,

"*... it could be argued that there is still considerable uncertainty concerning what it means to integrate findings in a mixed methods research project. The relative absence of well-known exemplars ... makes this exercise particularly difficult, as it means scholars have few guidelines upon which to draw..." (p.21)*

Synthesising both quantitative and qualitative data in a single study to address the broader issues of sustainable development may benefit from more visual diagrammatic strategies. Miles and Huberman (1994) provide multiple examples where a "matrix" can be used to connect both ideographic[8] and nomothetic[9] conceptions. Bazeley (2002) therefore suggests how,

"*Mixed methods often combine nomothetic and idiographic approaches in an attempt to serve the dual purposes of generalisation and in-depth understanding – to gain an overview of social regularities from a large sample while understanding the other through detailed study of a smaller sample. Full integration of these approaches is difficult, hence the predominance of component studies" (p.5)*

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[8] Idiographic is based on what Kant described as a tendency to specify, and is typical for the humanities. It describes the effort to understand the meaning of contingent, unique, and often subjective phenomena. (Wikipedia)

[9] Nomothetic is based on what Kant described as a tendency to generalize, and is typical for the natural sciences. It describes the effort to derive laws that explain objective phenomena in general. (Wikipedia)

In concluding his analysis of mixed methods, Bazeley (2002, citing Howe & Eisenhardt, 1990), explain how,

> "*... methodology must be judged by how well it informs research purposes, more than what matches a set of conventions... what counts for good research will not necessarily match what counts as orthodox methodology." (p.5)*

From this perspective, the present research was an ambitious undertaking that was subject to a multitude of challenges (as will be discussed in the final chapter). Significant cut backs to public sector services following the international banking crisis in 2008 resulted in the cancellation of the BSF programme. This in turn placed more pressure on the schools, the local authority and the private sector practitioners. The PhD's sponsor, Pilkington also disbanded their research division in 2009.

The researcher must therefore concede how the methodology was in part a reaction to the broader political and economic circumstances which prevailed during this period (2009-2013). Indeed, given the complexity of the numerous external challenges which threatened to undermine the research, by adopting Pragmatism as the preferred methodological paradigm, it was possible to adjust the research direction to accommodate these real world events. Moreover, whilst some aspects of the analysis could be described as cursory, given the scale and breadth of the research objectives, the methodological strategy can be justified.

In their literature review Jang *et al.,* (2008) differentiate between two types of mixed methods research. The first type they describe are 'component designs'.

> "*The component designs are distinguished from the integrated designs in that the different methods remain discrete through data collection and analysis and that mixing the methods takes place at the level of interpretation and inference. Examples of the component designs include triangulation, complementarity, and expansion designs" (p.222)*

Given how the current study has adopted a more complementary approach, Jang *et al.,* (2008) also describe how, *"A complementary mixed methods design aims for elaboration, clarification, and explanation by using different methods either within a single research paradigm or across different paradigms..." (p.223)*

By contrast,

"The integrated mixed methods designs differ from the component designs in that "mixing" takes place throughout the inquiry from data collection to analytic process and to interpretation." (p.223)

With limited experience in the field, the researcher employed a "component" approach to mixed methods as demonstrated by the 5 separate objectives. Interestingly, out of the various mixed-methods studies which looked specifically at schools, the physical environment was frequently omitted from their enquiries.

"A number of studies[10] *of successful schools in challenging circumstances have provided empirical evidence of school improvement and effectiveness by addressing themes related to instructional practice, leadership, use of data for school improvement, positive school culture, learning community, professional development and resources." (*Jang *et al.,* 2007, *p.224/225).*

Interestingly, various commentators within the field of sustainable design and educational architecture take the view that each school is unique, requiring a solution that is "context specific"..Similarly Jang *et al.,* (2008) explain,

"*There is an emerging voice that research on school improvement needs to be grounded in specific school contexts and to be sensitive to the unique challenging circumstances faced by each school – so that the inherent social inequities can in these school contexts be appropriately acknowledged and addressed" (p.225)*

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[10] *Hopkins (2001); Reynolds, Hopkins, Potter & Chapman (2001), Hargreaves & Fink (2006), Harris and Chapman, (2001), Leithwood and Steinback, (2002), Murphy (2002); Ryan (2006) Spillane (2006); Bernhardt (2004), Bray (2005), Connell (1996), Earl & Katz (2005), Hopkins (2001); Joyce, Calhoun, & Hopkins, (1999), Louis & Kruse, (1995), Henderson & Berla (1994); Muijis et al., (2004)*

3.9 Developing a theoretical model for Sustainable Schools

The present study has therefore adopted a more flexible approach when developing a conceptual model for sustainable schools. Importantly the notion that a single static blueprint exists which can inform and guide each and every school has been rejected. Instead, a mechanism which can both classify and connect different aspects of a system has been preferred. This in turn will hopefully enable researchers and practitioners to physically measure certain aspects of a school at the same time as understand the various dynamics which exists across the main themes synonymous with Sustainable Development.

Jang *et al.,* (2008), having conducted 80 interviews and 40 focus groups with teachers from 20 schools that were seen to be successful despite challenging circumstances were able to identify 8 important themes.

1. Distributed Leadership
2. Professional Learning
3. Diversity in Learning
4. Communication
5. Community outreach
6. School and classroom culture
7. Child's social and emotional , and behavioural development (SEB)
8. Parental involvement

It was therefore interesting to consider the extent to which the Ofsted reports and Parental Questionnaires tap into these less tangible concerns. It was also interesting to note how Jang *et al.'s* comment about the organizational aspects of carrying out a mixed methods project.

> "*Working as a team of faculty members and graduate students who brought multiple skills to the project, we all experienced the unique potential for enriching our understanding of schools facing challenging circumstances that integrative mixed methods data analysis holds" (p.243)*

A similar study by Ross *et al.,* (2007) identify a list of challenges which undermine the capacity to effect real change in the schools under investigation,

"*... many of the schools attempting to enact reforms appeared to lack a clearly stated mission, a safe environment, high expectations, instructional leadership, opportunity to learn, monitoring of progress, formative evaluation activity, external partners and effective communications." (p.138)*

They also acknowledge how,

"*... school change takes multiple years to produce implementation success and subsequent measurable effects on student achievement" (p.159).*

The current research was therefore keen to include 10 years worth of attainment (GCSE) data as part of longitudinal approach to evaluating the 'sustainable' performance of a school, albeit from an educational perspective. Ross *et al.,* (2008) also note,

"*... the simultaneous occurrence and interaction of multiple social, academic, administrative, and cultural events significantly complicates research efforts to isolate the effects of specific program components (Berliner, 2002,; Ross, 2003). Accordingly, it is possible only to speculate from our data as to which elements of KIPP:DA had substantive impacts. Clearly, for today's schools, the culminating criterion for judging a program success is student achievement (U.S. Congress, 2001). It is therefore relevant to consider that one of the school variables most consistently and strongly linked to student achievement gains is increasing allocated instructional time (Bloom, 1980) and, even more directly, students' time on task or engaged time (Good & Brophy, 1987). In this regard, KIPP:DA's extended school day and year acquires obvious importance as a primary program element" (p.159)*

In a similar vein, the new buildings delivered through the BSF programme were designed to create a more enjoyable and satisfying learning experience, which in turn may help incentivise students to engage in their studies for longer periods of time.

More generally, the paper by Bazeley (2010), *'Metaphors for integrated analysis in mixed methods researcher'* has influenced the current project in a number of ways. Firstly the use of a matrix was seen to be a helpful way to conceptualise an interactive system. This technique also affords different permutations to exist, reflecting the context-specific reality of each school. This tailored approach also helps to accommodate the different elements associated with Sustainable Development. Indeed, by selecting the 5 Capitals Model as the preferred framework, each "capital" has initially served as a thematic lens through which to formulate judgements about each school. Moreover, as the researcher began to synthesize the information contained within the literature review, it has been possible to tailor the 5 capitals model around the context-specific circumstances of designing, constructing and operating a school more sustainably.

From a methodological perspective, the approach taken here is not entirely dissimilar from the "dialectic" position which advocates that a "deeper understanding" (Greene, 2007) can be acquired if both quantitative and qualitative data are deliberately included in a single study. However, as Bazeley (2010) explains,

> "*The problem is that mixed methods researchers are assuming a shared understanding of commonly used metaphors which may not exist because the field is still young and complex" (p.1)*

Bazeley (2010) has therefore created a list of metaphors which help clarify the meaning of vocabulary used to describe mixed-methods research projects.

Table 12. Mixed Methods Metaphors (MMM)

Mixing Purpose	**Metaphor**		
Combining for completion	Bricolage	Mosaic	Jigsaw
Combining for enhancement	Sprinkling	Stirring	
Combining to create something new or different	Blending		
Pointers to a more significant whole	Triangulation	Drawing an accurate line	Archipelago
Linkage via a network	Chain	Web	Meshing or Weaving
Iterative exchange	Conversation	DNA	
Transformative (change) metaphor	Morphing	Fusion (partial, cell, nuclear)	Fisson

Source: Bazeley (2010)

In this regard , the purpose and metaphors which best match the current approach include the 'jigsaw' (combining for completion), and to a lesser degree 'blending' (combining to create something new) which Bazeley (2010) defines as follows,

> "*A Jigsaw is similar to a mosaic, except that each part has to fit into a particular place to make the whole picture so the design is very much pre-set. Jigsaws suggest puzzling, as the pieces are gradually matched on colour and shape and fitted together to contribute each building block to the whole" (p.4)*

> "*In one approach to blending, information from a variety of sources are merged together to create a richly detailed portrayal of a case, experience, event, process such that it would be difficult for any reader to deconstruct it into the particular bits that were put together to make the whole" (p.6)*

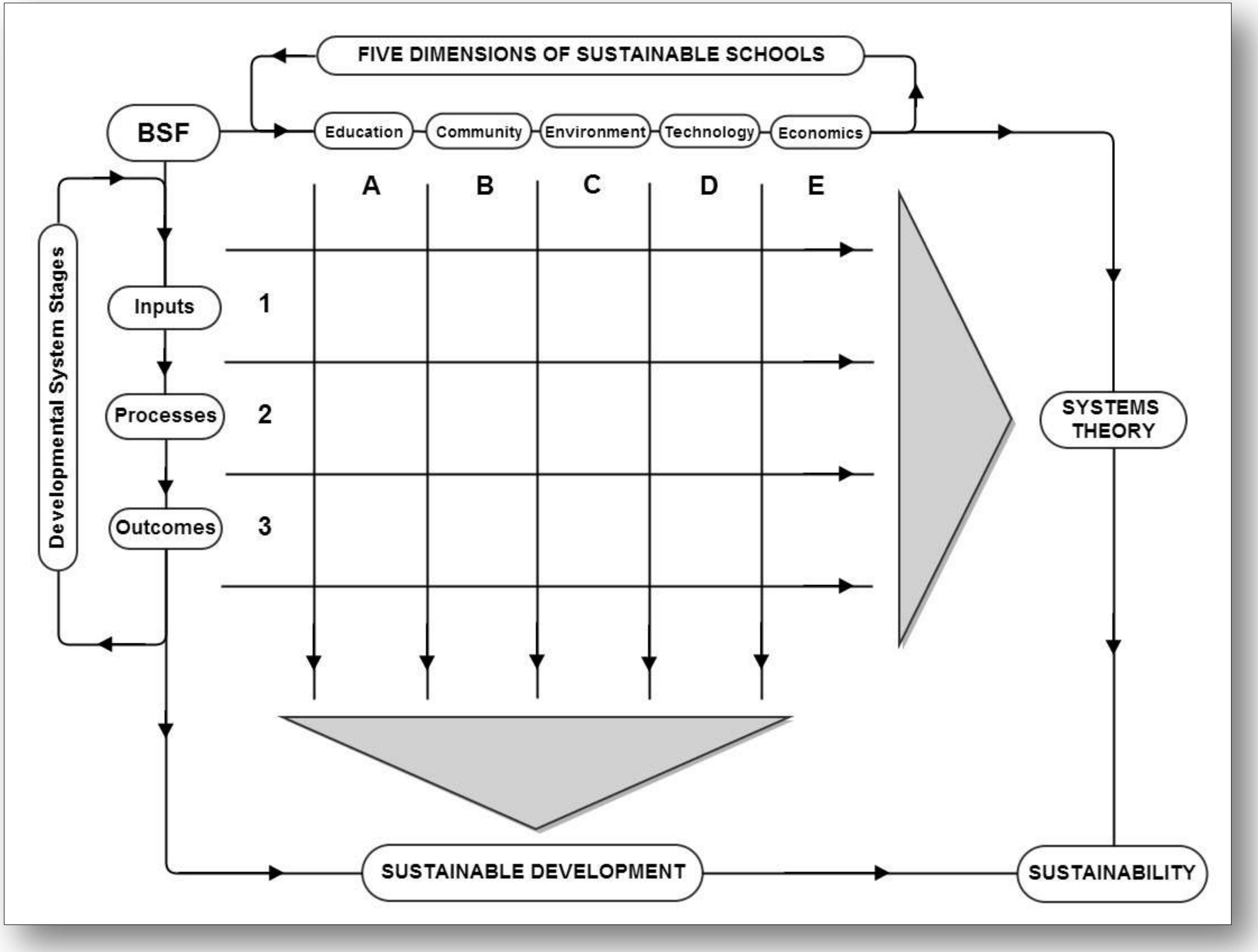
Finally, it has now been possible to synthesize all this information in order to address the project's overarching aim. Firstly the researcher elected to replace each "capital" with an equivalent "dimension". It was felt that a "capital" was more indicative of an "output" or "outcome" whereas the word "dimension" was more flexible, more able to accommodate a "systems" approach that distinguishes between "inputs", "processes" and "outcomes".

Secondly, the generic themes set out by the 5 Capitals Framework have been tailored specifically for schools. Furthermore, the researcher has also included a hierarchy by ordering the 5 dimensions in order of importance.

1. Education => equivalent to "human" capital
2. Community => equivalent to "social" capital
3. Environment => equivalent to "natural" capital
4. Technology => equivalent to "manufactured" capital
5. Economics => equivalent to "financial" capital

What has emerged is 5x3, 15 box matrix which brings the range of topics into a single framework which can now be applied to the four case-study schools as part of this study's original methodological approach (and contribution to knowledge).

Figure 20. Sustainable Schools Matrix (Conceptual Model)



Chapter 4 Procurement

This chapter introduces the reader to Leicester City Council, setting out the Local Authority's commitment to Sustainable Development and summarising the mechanism which would deliver the BSF programme. The actual analysis is presented chronologically, more like a narrative, seeking to validate or falsify the following conditions based on both documentary evidence as well primary qualitative feedback (what people have said).

(i) The council's output specification prioritised energy efficiency.

(ii) Relations and communications between the stakeholder groups were agreeable and effective.

(iii) Exposure to different types of project risks were appropriately managed.

(iv) Contractual incentives were in place to promote energy efficiency post-occupancy.

4.1 Leicester City Council (LCC)

In 2005, Leicester City Council's "One Leicester" strategy set out the broad aims of the Local Authority. Linking the condition of the built environment to the known social and educational problems, the BSF programme was designed to regenerate particular communities in distress.

Their mission statement summaries their aims:

> *"One Leicester – Uniting Leicester City Council and its partners in their shared goals to create confident people that share in a new prosperity, living and working in a beautiful place." (p.2, LCC, 2005)*

This statement draws attention to both quality of life ("a new prosperity") as well as the physical environment ("...living and working in a beautiful place"). These same themes were in evidence throughout the government's Every Child Matters report (2003) which made a concerted effort to link the welfare of children with the physical environment. Building upon these linkages, the council's BSF 'Strategy for Change' document sets out in detail the way in which the investment will have a direct impact on the lives of children. From this perspective, Leicester City Council had a clear social and educational narrative when applying to become a wave 1 BSF local authority. As part of their education drive to raise the level of attainment across the student population, the Strategy for Change report makes it clear where Leicester's schools presently stand.

> *"Attainment at KS4 has seen a steady increase... over the last 4 years with 39.9% achieving 5 A* to C grades, including English and Maths in 2008. However this is still significantly below the national average (47.6%)." (p.3, SfC, 2008)*

In one school which serviced an area of high social deprivation, "parental engagement" was identified as a key factor in helping to raise academic levels of performance (Ofsted rated this school "outstanding" on three consecutive occasions). In a similar fashion, BSF schools would need to reach out into the communities they serve.

To support and develop the council's education strategy, 3 objectives were identified as part of the council's BSF application,

1. *Strengthening traditional links with their community **[B]** to support agendas such as extended services and adult learning **[A]**.*
2. *Schools working with other schools as part of a city wide 0-19 learning strategy. **[B]***
3. *Agencies focused on the well-being of children to work more closely with schools. **[B]***

Furthermore, the updated Strategy for Change (SfC, 2008) report describes how the provision of ICT will enable *"...a step change in educational performance and behaviour*" through the ability to deliver personalised learning. Indeed, with the report explaining how "*some communities within Leicester face real challenges with regards to deprivation, family break down and a prevalent drug culture*" **[B]**, tackling disadvantage would require,

> "... *radical and transformational plans for school governance, school leadership and school buildings can be addressed through the BSF programme" (SfC, 2008)*

Once Leicester had successfully entered the BSF programme, £235million **[E1]** was allocated to the local authority to renew all 16/17 secondary schools. As part of the first wave of BSF local authorities, Leicester City Council would now be on a steep learning curve.

At the same time, the concept of Sustainable Schools was being developed by the Department for Children, Schools and Families (DCSF), culminating in the development of the 8 Doorways Framework. Moreover, not long after the BSF programme was announced, the Stern Report (2006) recommended that carbon emissions **[C]** would need to reduce in order to safe guard the stability of the economy **[E]**. As a result, the notion of "sustainable" communities would need to play a role in the procurement of the BSF programme. Indeed, with power devolved to local authorities the BSF programme was taking a big gamble. Not only would local government be responsible for the management of PFI contracts to deliver the schools, "sustainability" was a new idea which needed to be defined specifically for schools entering the BSF programme. Leicester's environmental credentials in this respect dated back over 20 years as the SfC report confirms,

> "*Leicester was Britain's first 'Environmental City' and we have established a reputation for our international contribution to tackling climate change. Sustainability is central to our ethos and way of working and this includes not merely designing sustainable buildings and facilities but also encouraging and supporting Sustainable Business and economic success and sustainable communities. Our 25 year vision is to be Britain's most sustainable city" (p.19, SfC, 2008)*

Indeed, to bolster their commitment to the government's 2016 Zero-Carbon for schools target **[C3]**, Leicester City Council set themselves the ambitious target of 2013 to achieve this feat. This would therefore mean that the BSF schools would need to significantly reduce their carbon emissions. More generally, Leicester City Council was hoping to reduce their total CO_2 emission by 50% before 2025 (based on 1990 levels) explaining how '*young people are at the heart of our plans to tackle climate change'* (p.19). As a result, the BSF programme employed a new procurement system that was designed to create the efficiencies necessary to achieve these educational, social and environmental aspirations.

4.2 BSF Procurement

This section briefly summarizes each stage in the BSF procurement process

4.2.1 Stage 1 (0 – 7 months): Inception

The first two months of the BSF programme require the local authority to consider what they want. Two documents are produced during this time – the Project Initiation Document (PID) and the Strategy for Change (SfC) document part 1.

The PID includes remit meetings, mobilising the leadership and governance strategy and confirming the budget. The project team are also assembled including the appointment of advisors. The SfC (1) document provides the strategic overview which is then submitted to Partnerships for Schools and the Department for Children, Schools and Families (DCSF) for approval.

Part 2 of the Strategy for Change document contains more detailed information about the delivery plan and should be completed within the first 7 months.

4.2.2 Stage 2 (0 – 12 Months): Prepare

A further report titled, “Outline Business Case” provides information about the feasibility and affordability of the proposed strategy. This is then submitted for approval to PfS and DCSF. Once, accepted, applications are either granted full planning permission or reserved.

A Readiness to Deliver (RtD) report then confirms the local authority has the necessary funds and proposals to consider the process of tendering and bidding. Indeed, in later guidance literature, Local Authorities were encouraged to engage with the Design Quality Index, developed by CABE, which provides a framework to assess the quality of the design **[D2]**.

4.2.3 Stage 3 (0 – 27 Months): Competitive Dialogue

This stage involves registering an application with the Official Journal of the European Union (OJEU), a requirement for all European contract tenders above a certain value. The OJEU will then issue the local authority with permission to proceed. Private Sector Partners may then be selected and invited to respond to the 'Statement of Requirements' and the Pre-Qualification Questionnaire. The Invitation to Participate in Dialogue (ITPD) is sent to a large selection of contractors.

The Invitation to Continue Dialogue (ITCD) then considers each application in more detail. PfS (2006) emphasised how each bid is to be treated fairly and how the details of each application are kept confidential.

The Invitation to Submit Final Bid (ITSFB) requires the remaining applicants to set out their intentions to become part of the Local Education Partnership. Partnerships for Schools, in conjunction with the Local Authority then selects their preferred bid based on the following criteria.

1. Commitment to the LEP mechanism
2. The sample designs for phase 1 schools **[D]**
3. The ICT provision **[D]** to facilitate "Educational Transformation" **[A]**
4. The legal and commercial considerations
5. The financial considerations **[E]**

Nb. No explicit mention of "sustainability" was in evidence!

4.2.4 Stage 4 (0 – 30 Months): Final Business Case (FBC)

This section of the procurement process involved further negotiations with the successful bid team. The FBC includes details about the contractual arrangements between all parties based on the commitments set out during the Competitive Dialogue phase. The content of this report needs to then be approved by PfS and the DCSF. Once this is done, the Local Authority, the bid team, and PfS sign a contract which officially establishes the Local Education Partnership.

4.2.5 Stage 5: Final Contract

The BSF Shareholder Agreement (SHA) is a contract between the parties forming the LEP. The shareholders entering the SHA includes the LA (10%), the BSF investments LLP (10%) and the Private Sector Partner (80%). The formation of the LEP is finalised by the signing of a 10 year Strategic Partnering Agreement.

4.2.6 Stage 6: Creating the "Local Education Partnership" (LEP)

The LEP is a Public Private Partnership (PPP) specifically designed to meet the needs of the BSF programme. According to the 2008 guidelines published by Partnerships for Schools,

> *"The LEP is a company that will provide long-term partnering services for the local authority so that the aims of BSF can be delivered. It is a joint venture company comprising the local authority, BSFI and a private sector partner."*

Accordingly, the rationale behind the LEP model aimed to;

1. Reduce the number of competitive procurements that had to be carried out and streamline the procurement process
2. Involve a strategic partner to deliver the long term programme
3. Group schools together into large, high value packages **[E]**
4. Optimise impact on education outcomes **[A]** by integrating building design and ICT **[D]**
5. Use both design & build and PFI contracts **[E]**

Nb. Again, no explicit mention of "sustainability" was in evidence!

In practice, setting up the LEP was taking too much time and costing too much money. By 2008, guidelines were adjusted to reduce the competitive dialogue period from 82 weeks to 74 weeks, which was then further reduced to 52 weeks as the Labour government began to fast-track the BSF programme.

Uncertainty about the LEP model was highlighted in a number of subsequent reports by the NAU (2009) and the WSBF (2009).

Staffing LEPs around the country was another area where delays in the commencement of the BSF programme resulted in inefficiencies mainly due to intermittent workload demands. It was therefore suggested in the WSBF (2009) report that Partnership for Schools should provide a centralised team which could be hired by local authorities to help identify the strongest bid team and set-up the LEP. At the same time, the LEP model was criticised for being too restrictive,

> *"... the local authority is procuring a consortium of companies and loses the ability to select individual suppliers. This often means that in procuring a LEP there will be one or more suppliers within it, whose bids are weaker than their equivalents in other LEP tenders. The manifestation of this issue has been particularly noticeable in the area of design... while the integration benefits of LEPs are undoubtedly valuable, they cannot be allowed to permit poor design." (WSBF, 2009, p.35)*

In terms of the legacy of the BSF programme, monitoring these schools using the various POE techniques will hopefully ensure future programmes are managed more efficiently. The current research has therefore rejected the argument put forward by Partnership for Schools (2008) when they suggest,

> *"The difficulty presented by benchmarking is that in a programme such as BSF there is an almost infinite amount of information, the collection of which would make any database unmanageable. There is a further problem that data will always be context specific with factors such as labour costs and even building techniques differing across the country."*

The conceptual model developed for this project may help to address these issues. Indeed, the actual procurement analysis will now respond to the following four conditions.

(i) *The council's output specification prioritised energy efficiency.*

(ii) *Relations and communications between the stakeholder groups were agreeable and effective.*

(iii) *Exposure to project risks were appropriately managed.*

(iv) *Contractual incentives were in place to promote energy efficiency post-occupancy.*

4.3 The Output Specification: Condition (i)

This section specifically looks at Leicester City Council's BSF team. The formulation of the brief, referred to as the Output Specification, was an important part of the BSF programme. Evaluating the extent to which sustainability and energy efficiency played a part in this process has been considered along with more general matters.

To start with, Leicester City Council had to assemble an in-house BSF "Project Team". However, as a wave 1 council there were no past examples on how to apportion the budget (£235m) to effectively resource the administration side of the programme.

In the years which followed, CABE advised government that all second and third wave local authorities must appoint an independent Client Design Advisor (CDA) for the many reasons set out on the table below.

Table 13. CDA Responsibilities [C], [D], [E]

<table>
<tr><td colspan="3">What is a client design advisor? A client design advisor (CDA) is a skilled experienced architect who can advise the LEA on all aspects of design for each school and can help to achieve high quality buildings and environments...</td></tr>
<tr><td>Preparation Stage</td><td>Design Stage</td><td>After formation of the LEP</td></tr>
<tr><td>Consultation and facilitation: involving the schools when identifying 'key design issues and aspirations'</td><td rowspan="2">Using DQI's and BRE's environmental assessment method (BREEAM) to evaluate the design proposals.</td><td rowspan="2">The role of the CDA reduces following the formation of the LEP and during the development of subsequent (non-sample) schemes. However the CDA continues to be an important source of advice to the LEA and to individual schools as new briefs are prepared and designs proposed.</td></tr>
<tr><td>Exploring options and feasibility: justifying the cost and design factors</td></tr>
<tr><td>Brief development: assisting with the preparation of output specifications</td><td>Checking the contract documentation to ensure that the designs in the detailed drawing and specifications meet the standard requested in the brief</td><td rowspan="2">There is a risk over time of compromise of the standards of non-sample schemes and of failure to achieve promised improvements. The CDA's continuing presence is one means of avoiding this risk</td></tr>
<tr><td>Contributing to selection of private sector partner: establish weighting to architectural design, technical details, operational issues and educational ethos</td><td>Negotiating the final design and technical details with bidders</td></tr>
</table>

Source: Adapted from CABE (2008)

When the in-house “project team” was eventually assembled (see appendix), the Project Director, a former Head Teacher with experience dealing with construction projects, assumed most of the responsibilities which a Client Design Advisor would be responsible for (table 13). The team which would support him consisted of two project managers and three administrators. However, the team did not have any previous PFI experience. Any further support during the initial stages of procurement was provided by the local authority’s Education Department. Significantly, the council’s sustainability manager subsequently remarked,

> *“ ... you get a big sum of money... but no additional money to support the administration ... and there’s no extra funding later on... so I think the project team were having to understand this situation on their own before other departments in the authority could get involved.”*

In terms of the energy efficiency of the programme, there was some confusion between the desire to incorporate more ICT as part of the push to “transform” education, whilst at the same time reduce carbon emissions. Again, since BSF guidelines did not include specific operational performance targets in terms of energy (kWh/m²/p.a.) or carbon ($kgCO_2/m^2/p.a.$) the output specification attached a weighting of only 10% to design quality. Furthermore, since design quality was assumed to include “energy efficiency”, the bidding teams were not encouraged to prioritise low-energy into their bid proposals. As a result, it was only the BREAAM regulatory design requirements which ultimately dictated the extent to which “sustainability” would be addressed.

In responding to condition (i) there was little evidence to suggest the phase one output specification prioritised energy efficiency, other than to ensure new builds and refurbishments achieved the BREEAM ratings of “Excellent” and “Very good” respectively. It was also noted how the decision to include biomass at two of the sites was motivated, not by design, but the BREEAM regulation and the council’s 11% renewables policy[11]. This is discussed in more detail under the biomass section (page. 209).

There was also a general sense among the practitioners that the local authority’s desire to deliver zero-carbon schools (by 2013) was unrealistic both in terms of budget **[E]** as well capability **[D]**.

[11] All projects are required to generate at least 11% of their energy from low-carbon/renewables sources on site.

4.4 The “Bidding” and “Design” Phase: Condition (ii)

For any wave one council entering the BSF programme, procuring the first phase of “sample” schools would inevitably be the most challenging aspect of the procurement process. Managing this process would rely on good relations and good communications between the various public and private sector partners. This section looks at the structures and mechanisms which both encourage and inhibit the development of productive and effective professional relationships developing within the BSF procurement mechanism.

In May 2005, Leicester City Council published the OJEU (Official Journal of the European Union) notice inviting bid teams to apply. With a deadline for the selection of the preferred bid team set for September 2006, once the ITCD (Invitation to Continue Dialogue) application had been processed, bid teams were then able to submit their applications to participate. Based on the initial applications, three bid teams were selected. It was then left to Leicester City Council to arrange consultations between the schools and the three competing design teams.

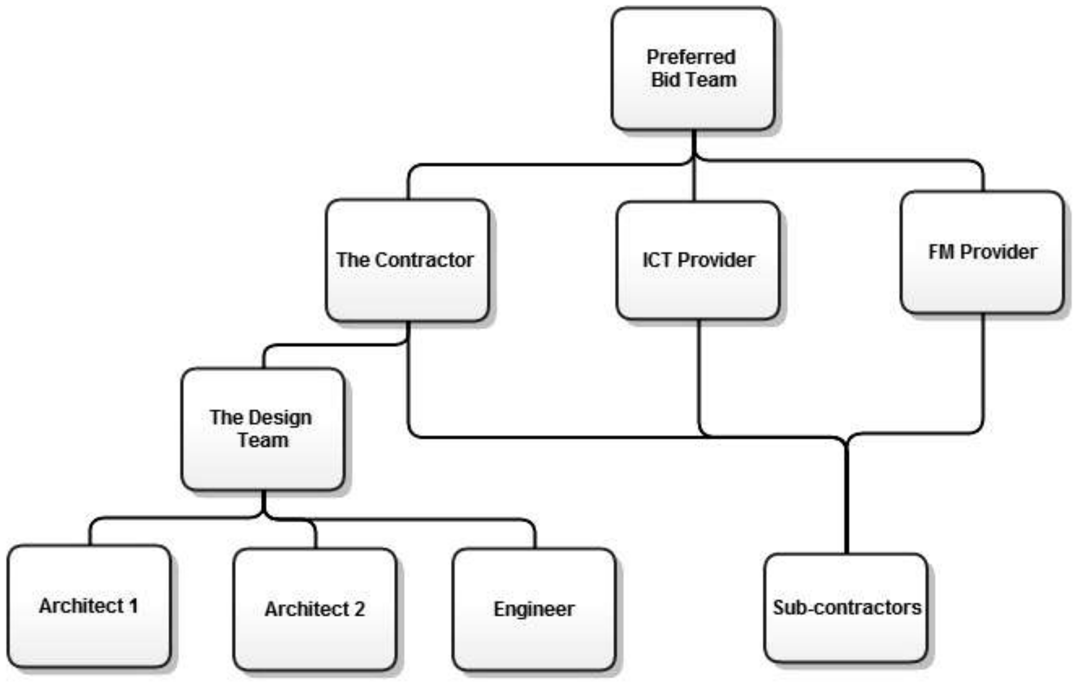
The initial “engagement” process lasted for approximately 6 weeks during which time all four schools spent an equal amount of time with each design team. The Business Managers have confirmed how this commitment to the BSF “engagement” process was extremely time consuming, especially as they had to manage their usual day to day responsibilities without any additional support. The design teams also felt that 6 weeks was not enough time to liaise and consult with the schools so they could prepare a fully formed solution as part of the private sector selection process. In this regard, the time restraints set out by the BSF competitive bidding mechanism created substantial levels of exhaustion which all parties involved confirmed.

As a result, with the output specification allocating a nominal weighting of 10% to the design quality, the standard of the design proposals were not sufficiently high, nor did they explicitly incorporate conventional or innovative solutions which set out to improve energy efficiency. Furthermore, in the absence of a Client Design Advisor (CDA), the focus of attention centred around the delivery of the PFI contract rather than delivering low-carbon buildings. Moreover, with the decision not to include other departments within the local authority, sustainability as a design imperative was mostly abandoned.

A = Education; B = Community; C = Environment; D = Technology; E = Economics

Looking now at the relationships between the private sector partners, figure 20 illustrates how the main contractor appointed the design team whilst the FM and ICT providers were mostly 'one-step' removed from the early engagement activities, having only minimal influence over the actual design decisions.

Figure 21. Organizational Hierarchy of the Private Sector Partners (PSPs)



Furthermore, once the council had awarded the contract to the contractor, they effectively conducted the proceedings thereafter and it was through them that the local authority would communicate. Similarly, each school's BSF team, which normally included the head, the deputy and the business manager (formerly the caretaker), generally liaised with the Design Team. However, the business manager at School B was disappointed when he explained how the design team were replaced by another group of architects when the successful contractor had been identified. Indeed, having already established an understanding with the previous design team members, this new appointment was regarded as unhelpful and counterproductive.

By the time financial close was achieved in December 2007, the creation of a new company, Leicester Miller Education Company was formed. LMEC, in conjunction with Leicester City Council would then form the Local Education Partnership (LEP) as part of the final stage of the BSF procurement mechanism, identifying September 2009 as the deadline for completion.

Indeed, with the contractor keen to get started, when finally the LA planning department and property services were required to sign-off the four final design solutions, further alterations were identified. As a result, the private sector partners expressed their frustration about the way the Local Authority had not raised these concerns at an earlier stage in the design process. These last minute changes also created tensions between the schools and the LA. Indeed, had an independent advisor (CDA) been in place, this type of issue could have been avoided. As a result, one head teacher remarked,

> *" ... never let the local authority design a school for a school. Always use the professionals or else you will end up with a box as opposed to a building which can't improve teaching and learning. And the biggest thing is to involve the head teachers and the senior teams and the finance that can make that happen. The local council are arrogant and think that they are experts in management consultancy and can design the best schools! They can't." (Head Teacher, School C, 2009)*

Moreover, the business manager at School B explains how design decisions were then taken without any consultation with the schools.

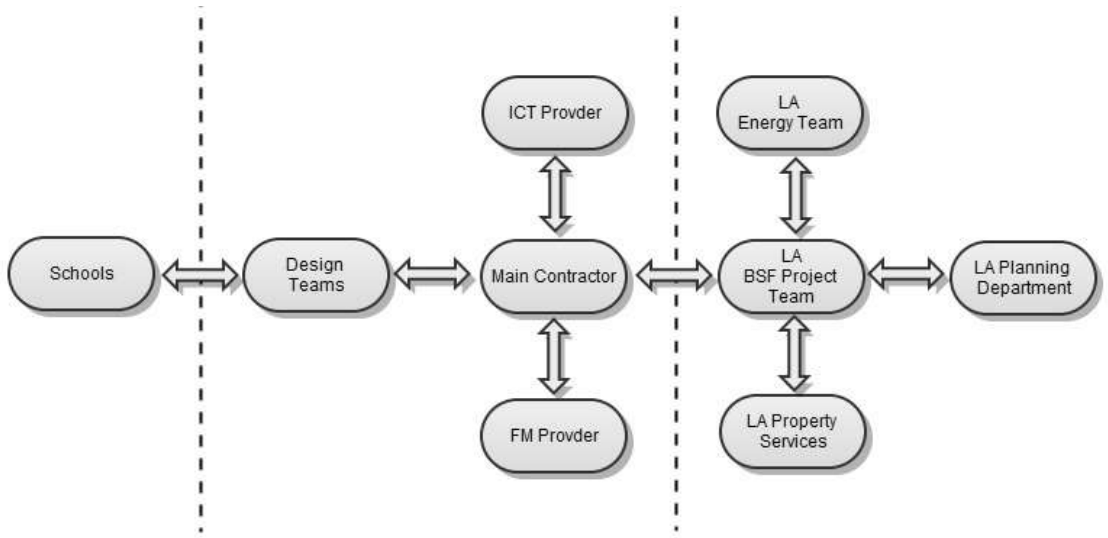
> *"The original design of the school was supposed to have a 'brise soleil'... cost-cutted, there was no justification or discussion about what mechanical issues were to be omitted from the actual build" (Business Manager, School B, 2010)*

Under the circumstances, due to the belated involvement of the 'other' local authority departments, time pressures and financial constraints were having a detrimental effect on relationships between the various stakeholder groups. Indeed, as the Business Manager explains below, protecting some aspects of the original specification required additional funds to be found.

"*CCTV is so important we paid £30,000 of our own money as it was value-engineered out... and without consultation with the school... the city council decided if there were to be cut backs it would be access and security... the FM provider wants CCTV to protect the building... but we wanted CCTV on the inside to manage bullying etc... So CCTV is part of everyday management.*" *(Business Manager, School B, 2010)*

The diagram below illustrates the lines of communication which exist. Too often a lack of "direct" communication limited the capacity to resolve issues early on. Moreover, the architects have since confirmed how their participation quickly diminished once their designs were completed. Traditionally the architect would project manage a build, making adjustments along the way. Nowadays, with so many separate stakeholders and sub-contractors working on a single project, the need for integrated project management systems like 'The Soft Landings Framework' becomes more important. Indeed, with the political pressure to deliver the BSF programme on time, fast-tracking the design and consultation phase will only compound these problems.

Figure 22. Stakeholder Communications



Indeed, it has been helpful to consider the commercial circumstances and interests of each stakeholder when seeking to identify flaws in the operational set-up of the BSF programme.

Firstly, the main contractor was also a private equity provider, contributing up to 80% of the capital funding over a 10 year period (£235-300m). As the "majority" share-holder (so to speak), they became the primary decision maker through which design negotiations would be agreed. Their focus was to achieve their regulatory and contractual responsibilities whilst optimising their profit margin. However, the BREEAM design requirement was a relatively new piece of regulation which the contractor struggled to understand. As a result they choose to employ a specialist consultant to advise them on how best to achieve the required BREEAM points (Very good > 50 pts; Excellent > 70).

By contrast, the FM team were less concerned about BREEAM compliance, and more worried about the operational efficiency and effectiveness of the buildings post-occupancy. As such, any short comings at the design, construction or commissioning stage would have negative implications for their long term (10 year contract) commercial interests. Bizarrely, neither the FM or ICT provider were actively involved in the initial bidding, consultation or design phases.

In this regard, the conflicting interests of both contractor and FM provider resulted in disagreement about the contractual responsibility of building performance post-occupancy.

From the design team's perspective they were hired by the contractor to initially win the contract and then satisfy the requirements of the schools within the limitations of the budget which the contractor ultimately determined. Once the bidding and design phase were over, their involvement discontinued. Traditionally, architects would project manage the construction, adjusting their solutions as and when different issues arose. This was no longer the case.

The schools were clearly focused on creating a brief which tackled the inadequacies of the existing buildings, whilst developing a "vision" that encompassed the aims and objectives set out by the BSF programme's "Educational Transformation" agenda. However, with the Local Authority acting as "client"; making decisions on behalf of the schools without routinely consulting them first, resulted in further tensions between the two public sector parties.

Finally the Local Authority, who were ultimately accountable for the entirety of the project, were understandably concerned about the capital costs and subsequent running costs. Indeed, as one member of the council explained during a walk-round inspection at School B,

> "*Energy is at the top of the agenda at the council. At present the new schools are using approximately 50% more electricity" (LCC project team member, 2010).*

More recently the council, in their 2010 report, acknowledge how,

> "*... improving the sustainability of the first phase of our BSF project has been problematic. We have reviewed this and identified that opportunities were lost because of the procurement process and the need to strictly control engagement with students and staff and limited opportunities to introduce third party funding due to the complexities of the PFI and FM contracts" (2010, LCC)*

Moreover, it has now come to light, following the cancellation of the BSF programme nationwide, how the remaining 12 BSF schools in Leicester will be financed using conventional "Design and Build" contracts. Evidently, the reality of procuring schools using the new BSF-PFI model was proving to be a challenge for the local authority.

Under the circumstances, condition (ii)[12] was not broadly achieved throughout the procurement of phase one.

[12] ... relations and communications between stakeholder groups were agreeable and effective.

4.5 Project Risks & Contractual Incentives: Condition (iii) & (iv)

Building regulations can be interpreted as project "risks" which the developers are then responsible for. Building Bulletin 101 sets out what has been described as "Availability Risks".

> "*Ventilation should be provided to limit the concentration of carbon dioxide in all teaching and learning spaces. When measured at seated head height, during the continuous period between the start and finish of teaching on any day, the average concentration of carbon dioxide should not exceed 1500 parts per million" (BB101)*

> *"Temperature should not exceed 28 degrees for more than 120 hours" (BB101)*

Whilst the design team are responsible for delivering the required environmental conditions as set out above, their involvement discontinued at the point of construction. The contractors were then responsible for construction, but it became the responsibility of the FM provider to remedy the various HVAC problems post-occupancy. This "disconnect" between the design team and FM provider was compounded by the failure to effectively commission these services pre-occupancy. Evidently, the failure by the Private Sector Partners (PSP) to co-ordinate their efforts is consistent with the more general criticism directed toward the construction industry about the failure to co-ordinate an increasingly diffused work force of specialists. Indeed as Mumovic (2010)[13], the editor of the CIBSE School Design Group Magazine (April 2010) explains,

> "*The school design is often characterised by a piecemeal approach, with each professional working in isolation. This can lead to design conflicts – for example energy efficiency requirements can conflict with the architectural vision of a school building, or for example, ventilation system design. A lack of integration in the design process can lead to a built environment which does not meet the needs of its community... let's change the silo mentality characterising the current decision-making process for school design and operation. " (Foreword, p.2)*

One architect did express her frustration with the balance of power,

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[13] Dr Dejan Mumovic, The Bartlett, UCL, Secretary to CIBSE School Design Group

> "*Our priority is to deliver the best possible building for kids, but the contractor is inevitably focused on the financial decisions" (Architect)*

As the largest contributor of private equity, the contractor was ultimately responsible for managing "Financial Risk" and approving design decisions based on affordability criteria. However, when the contractor was asked about their responsibilities post-occupancy, they took the view that the FM provider had taken the decision to join the consortium and were fully aware of their commitments and responsibilities.

In terms of the FM contract incentivising the FM Provider to optimise energy efficiency, the "unitary" fee (annual service charge) would increase or decrease depending on the amount of energy consumed. To encourage a pro-active approach, the following conditions were established.

1. If consumption falls between 90% and 100%, the cost savings benefit the FM provider only.
2. If consumption falls below 90%, the cost savings are divided 50-50 between the FM provider and the School.
3. If consumption increases to between 100% and 110%, the FM provider pay the additional costs.
4. If consumption increases beyond 110% then both the school and the FM provider split the additional costs 50-50.

In order to address condition (4), whilst these conditions seem reasonable, the researcher in discussion with the Business Managers was unclear about their practical benefits. Firstly, the 100% energy consumption was discussed and could not be sufficiently clarified. It was suggested that BREEAM should calculate the 100% figure based on their design guidelines. However, the researcher has understood that the BSF contract used a standard formula based on the total floor space. Indeed, it can be argued that until such time as the building is in operation for at least a year, it is difficult to make a determination about what constitutes 100% energy consumption.

Secondly, as the FM provider was exclusively responsible for managing energy efficiency post-occupancy, the schools were effectively powerless. Furthermore, any improvements which deliver savings in excess of 10% could be interpreted as a disincentive due to the 50-50 sharing clause.

And thirdly, because the BSF contract only required a re-assessment of this 100% benchmark target every 3 years, once again, the FM provider had no immediate incentive to improve energy efficiency. Indeed, one could argue that deliberately running the building inefficiently, it would then be possible to deliver efficiency savings as and when it becomes more financially convenient to the FM provider. Moreover, apart from the inevitable complexities associated with the practical implementation and interpretation of these contracts, the business managers evidently needed support from individuals with experience in PFI and FM contracts. In this regard, CABE's advice to appoint Client Design Advisors beyond phase one was a much needed policy update.

To compound this problem, whilst the BREEAM regulatory requirement was effective in terms of obliging the contractor to address the "sustainable design" requirements, had they also taken a lead in terms of setting operational benchmark targets for each school, these problems may have been avoidable (with hindsight).

Indeed, as one senior consultant from the BSRIA[14] explains in an email to the researcher,

> "*We focus too much on tick-box [BREEAM] assessments and focus too much on design quality [BREEAM, CABE- DQI] (easily trumped by time and cost factors in the real world) and not enough on construction, pre-handover, initial operation and long-term aftercare. Also our forms of contract are way out of date. Partnering helps, as do Framework agreements, but standard contract arrangements, JCT[15] for example, are no longer fit for purpose" (18th March, 2010).*

So what conclusions can be drawn from the experiences of procuring phase one? First of all, the analysis has focused exclusively on the qualitative evidence, drawing attention to the "inputs" and "processes" associated with the procurement process.

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[14] Building Services Research and Information Association
[15]http://en.wikipedia.org/wiki/Joint_Contracts_Tribunal;
http://www.jctcontracts.com/JCT/pdf/JCT_News_October_2010.pdf

Furthermore, the narrative which has unfolded demonstrates that the four propositions were not supported by the evidence. That is to say, the BSF procurement mechanism did not encourage the development of a low-energy brief, nor did it facilitate the development of a harmonious partnership between the major public and private sector stakeholders.

Significantly, it was a combination of time constraints imposed by the BSF engagement process, budget limitations and (foreseeable) conflicts of interest emerging that gave rise to a range of operational and contractual complications post-occupancy.

This in turn made the researcher's job more difficult as he endeavoured to extract information about the operational problems which staff and students were now encountering post-occupancy. More importantly however, the ability to attribute responsibility was made more complicated by the fact that the consortium were made up of separate companies. In other BSF projects however, the 'preferred bid team' (Architects, builders, FM services) were all part of the same company, thus avoiding the commercial problems identified in this case-study.

In conclusion, the documented experiences from across phase 1 confirm how the procurement system was not able to satisfy the four conditions. In the future, it may be sensible to consider employing the Soft Landings Framework as a way to systematically document each phase in the construction cycle. Extending BREEAM's role to include operational benchmark targets would also incentivise the contractor to prioritise designs which reduce operational energy consumption rather than achieve arbitray points based exclusively on design quality. Selecting private sector partners who have a track record in delivering low-carbon solutions must therefore be prioritised. Furthermore, as the consultant from the BSRIA has confirmed, the current contractual framework is no longer 'fit-for-purpose'. Clearly, the regulatory and contractual arrangements must support the public sector client in order to provide value for money at the same time as reducing the education sector's carbon emissions..

Chapter 5 Design and Construction

*This section summarises each schools basic design specification using a range of drawings, photographs and construction documents which the Design Team provided. This documentary evidence contains both quantitative and qualitative information focusing mostly on the "technology" dimension **[D]** of the SS matrix*

5.1 School A

Image 1. School A

As part of Leicester's £60-65m phase one BSF programme **[E1]**, School A was part of Leicester's two "sample" schools procured using the standard "design and build" contract. Originally the project was pencilled in for a refurbishment but a feasibility study revealed that a new building would be affordable and offer a range of benefits. As a result, School A was allocated a budget of approximately £15m **[E1]** to create a new facility for 1,050 students **[A1]**.

The new build solution was also less disruptive for the school. The old school remained in operation throughout the construction phase, whilst the new building was constructed on the existing playing fields. Once the new building was complete, the old building was demolished and partially recycled **[C]**.

The new school's ICT infrastructure included 350 computers and laptops and 52 interactive whiteboards **[D]**. The ICT provider, Northgate manages a system across all four schools which they called "N-able". Each student is provided with a "smart card" **[D],** allowing morning and afternoon registration to be automated. It also provides a cash-free environment where parents can top up the card with money which in turn helps to reduce the potential for theft **[B]**.

Completed on budget, six weeks ahead of schedule, School A was officially opened on the 16th June 2009. Having won the prestigious BSF School of the year competition (2009), and with a BREEAM rating of 'Excellent' **[D]**, the head teacher and the project manager explain why they thought this project was so successful.

"*I cannot emphasize how pleased we have been with our relationship with the project and site managers **[B]** ... They have been exemplary in their attitude, their communication and their helpfulness." (Head Teacher, 2009)*

Image 2. School A's Moto

*"The co-operation, commitment and focus **[B]** of the school throughout the process has been fundamental to the project's success and the ability to be able to reach such a significantly early hand over." (Phase 1, Project Manager)*

The design team, limited by the budget **[E1]** was keen to involve the staff and students in some aspects of the design **[B]**. After some careful consideration, the colour scheme was an aspect of the design which the school had total control over. This resulted in staff and students expressing a greater sense of ownership towards the new building **[B]**, whilst allowing the professionals to make judgements about the more technical aspects of the design **[D]**.

The positive publicity which accompanied the success of School A makes this project particularly interesting given the budget limitations. Seeking to capture the socio-technical data also has important implications for the way practitioners liaise with schools as they attempt to deliver the best possible building. Indeed, as Dudek (2000) explains, the development of educational architectural has stagnated due to lack of investment. Indeed, with the emergence of ICT **[D]** as a main stream tool to support the teaching and learning process **[A2]**, feedback from fulltime staff becomes ever more important when delivering buildings which are ‘fit-for-purpose’.

The structure consists of a three storey, 180m long steel frame, with concrete floors supported by beams and metal decking **[D]**. The floor and partitioned ceilings contain most of the building’s services, which ensures a clean internal aesthetic and efficient use of space. Moreover, the floor plan below illustrates the simplicity of the building’s general layout.

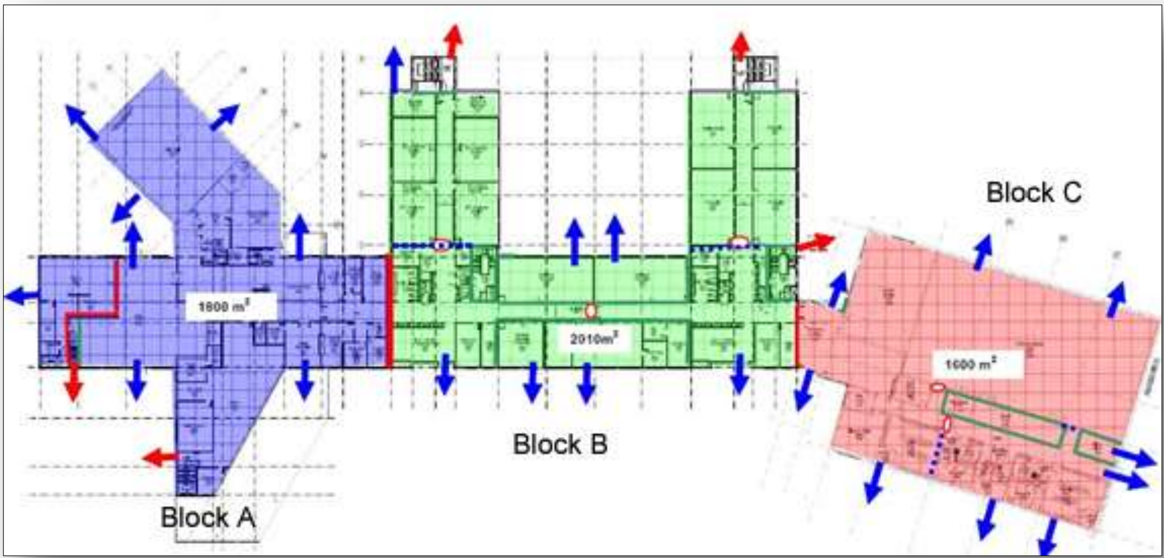


Figure 23. School A Floor Plan

Conforming to the 2002 building regulations (+24%) and BREEAM standards, the building’s external envelop was made mostly from bricks and render as image 3 illustrates **[D]**. Typically referred to as “curtain walling”, the engineering firm’s documentation specifies that the external walls have a U-value[16] of 0.27 W/m²K. The windows were double glazed aluminium, delivering a U-value of 1.8 W/m²K. The roof was made from steel and was rated at 0.16 W/m²K. Finally, the insulation of the ground floor was rated as 0.20 W/m²K.

Image 3. School A Outside Entrance – Block A

The simple design of the building was set across two and three storey blocks which figure 24 helps to convey. Block A, described by the architect’s as the “community zone” is approximately 3,500m² in size on the west side of the building and contains the library, the ICT resource suites, the dining hall and offices. Block B is larger and includes all 24 standard size classrooms over 3 floors (6,000m²). To the east, Block C had its own dedicated plant room to provide efficient heating and electricity for the sports hall, dance studio and changing rooms.

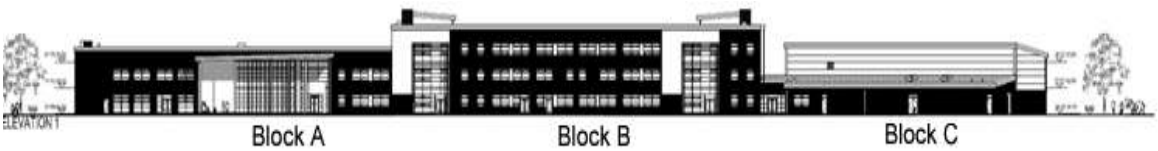


Figure 24. School A Landscape Elevation Drawing

[16] The U-factor or "U-value", is the overall heat transfer coefficient that describes how well a building element conducts heat or the rate of transfer of heat (in watts) through one square metre of a structure divided by the difference in temperature across the structure (source: http://en.wikipedia.org/wiki/R-value_(insulation)#U-factor.2FU-Value)

The general design of School A was simple and efficient. Future new build projects of a similar size (1000 pupils) may wish to copy the basic blueprint, whilst seeking to improve on the basic specifications, e.g. improving the thermal performance (U-values) of the building materials. If additional funding **[E]** is available, it may then be possible to consider more efficient heating (biomass) and lighting systems **[D]**.

The table below compares how the four external surfaces compare with the BSF guidelines which stipulate that new build BSF projects should be 24% more efficient **[C]** that the prevailing 2002 building regulations (BSF-L2A-2002).

Table 14. School A External Envelope Comparisons

External Surface	L2A (2002)	School A	% Improvement
Walls	0.35	0.27	23
Floor	0.25	0.2	20
Windows	2.2	1.8	18
Roof	0.25	0.16	36

Source: Gifford

With regards to the building services, conventional gas and electricity powered the building. A summary of the building's main components **[D]** have been summarised as follows.

- The main heating plant used conventional radiators to maintain an indoor temperature of 21°C using 3 low pressure hot water (LPHW) condensing boilers each rated at 300kW.
- The sports hall heating plant used Air Handling Units set to various temperatures, powered by 2 LPHW condensing boilers rated 100kW.
- Mechanical ventilation is delivered via ductwork to Blocks A, B and C. The fans are triggered if temperature levels exceed limits set by the BMS system.
- Domestic hot water (DHW) is delivered throughout blocks A and B using two gas fired hot water boilers rated at 124kW each.
- Domestic hot water in the gymnasium (block C) is powered by two 73kW hot water boilers.
- There was no primary air cooling device built into the HVAC system.
- Secondary air-conditioning was available in particular areas (ICT room etc).
- The lighting system mainly consists of linear fluorescent T5 strip bulbs, activated by PIR devices – motion detector sensors.

In summary, the limited budget **[E1]** ‘may’ have had a positive influence on the design process **[D2]**. As a result, the contractor focused on delivering a conventional building that was relatively easy to construct and commission **[D2]**. As a result, the building was completed well in advance of the September deadline, allowing more time for commissioning. This meant that the educational benefits **[A]** could be immediately realised as the building’s services were working correctly **[D]**. The qualitative evidence also demonstrates that the relationship between the school and the contractor remained positive throughout the project.

Furthermore, by engaging with the staff and students, by allowing them to select colour of the interior walls and floors, the less tangible benefits in terms of developing a sense of ownership and connection between the new building has also been helpful **[B]**.

In the round, School A was a successful project.

5.2 School B

Image 4. School B

School B was the largest of the phase one projects in Leicester. With a funding envelope of £21.5m **[E1]**, the new building has a floor area of 13,300m² [**D3]** to accommodate approximately 1300 pupils **[A1]**. Interestingly, whilst Gifford acted as the principle engineering firm across phase one, the main developer elected to appoint two firms of architects. At School B and School D the same architects (B) were employed.

Looking at the background information contained within the construction documentation, all three new build projects replaced 1970s CLASP structures, thus highlighting the limited life span of pre-fabricated buildings. By contrast, many Victorian Schools are still in operation. Most notable failures of the previous school were described by the architects as follows,

> "*The building fabric is unsatisfactory **[D]** and the internal spatial arrangements are inappropriate to provide quality-learning environments **[A]**... to deal with security issues ... the school is behind a large palisade fence and accessed by visitors through a remotely*

> *controlled security gate. The school does not present a welcoming external image **[B]**." ('Strategic Business Case, SBC Report by Leicester City Council)*

In addition, the link between build quality and occupancy performance was highlighted in the planning statement,

> *"The key issues facing the school are the poor quality of its existing buildings and the negative impact this has on the morale of staff **[B]** and learning of students **[A]**."*

Similar to the previous two projects, School B was built around a steel frame with concrete floors, standing seem steel roof, Trespa panelling, Kingspan insulated walls, and aluminium double glazed windows. In conjunction with two specialist installers, SAS (Senior Architectural Systems – window, door and curtain walling manufacturers) and Acorn Aluminium (leading building fabric manufacturer), 60% of the building's facade consisted of some form of external glazing.

Image 5. School B External Envelope

Quoting from the SAS documentation,

> "... *with such large spans of glass incorporated within the facade, the fabrication and installation process of the curtain wall had to be precise **[D2]**... the challenge around the project was ensuring the interface between curtain wall and the cladding on the building was accurate and that it would contribute to the overall environmental and performance objectives set by the architects" (Managing Director, www.seniorarchtitectural.co.uk)*

Indeed, whilst the BSF minimum target for air-leakage was set at 10m³/m²/per hour based on the 2006 part L regulations, when the building was evaluated by Stroma Technology as part of the compulsory UKAS[17] accredited air-tightness test, the building achieved the target set by the

[17] United Kingdom Accreditation Service

design team of 5m³/m²/per hour, twice as good as the regulations. This example highlights why involving the component manufacturers during the design and construction phase is essential. Details about building external insulation performance have been listed below. As a reminder, BSF guidelines advise that new build projects should be 24% more efficient than the 2002 building regulations.

Table 15. School B External Envelope Comparisons

External Surface	L2A (2002)	School B	% Improvement
Walls	0.35	0.27	23%
Floor	0.25	0.2	20%
Windows (SAS/Acorn)	2.2	1.8	18%
Roof	0.25	0.16	36%

Source: Engineering Firm

To support the project's sustainability credentials, a mix-mode ventilation strategy was proposed with a 65% heat recovery system. Looking to benefit from the site's exposed location in a similar fashion to School C, both natural and mechanical ventilation were designed to operate in together in order to create a stable and comfortable indoor environment.

In terms of the layout, the three protruding teaching wings had atriums built into the roof in order to allow more natural light to enter the open plan corridor spaces. However, it was doubtful whether these spaces satisfied BSF's 2% daylight criteria [D1] for 'non-teaching' spaces. Indeed, when an inspector from Partnerships for Schools visited the building, he was critical about the choice of floor and wall colours. Moreover, when a lighting expert from the IESD also inspected the building he too criticised the choice of colours, explain that lighter colours would improve lux levels by 50%. He was also critical about the opaque glass in roof, which not only reduced the amount of natural light but created a glare effect more typical of artificial lighting. Indeed, as the pictures below help to illustrate, artificial lights were frequently switched.

Figure 25. Natural Light concerns at School B

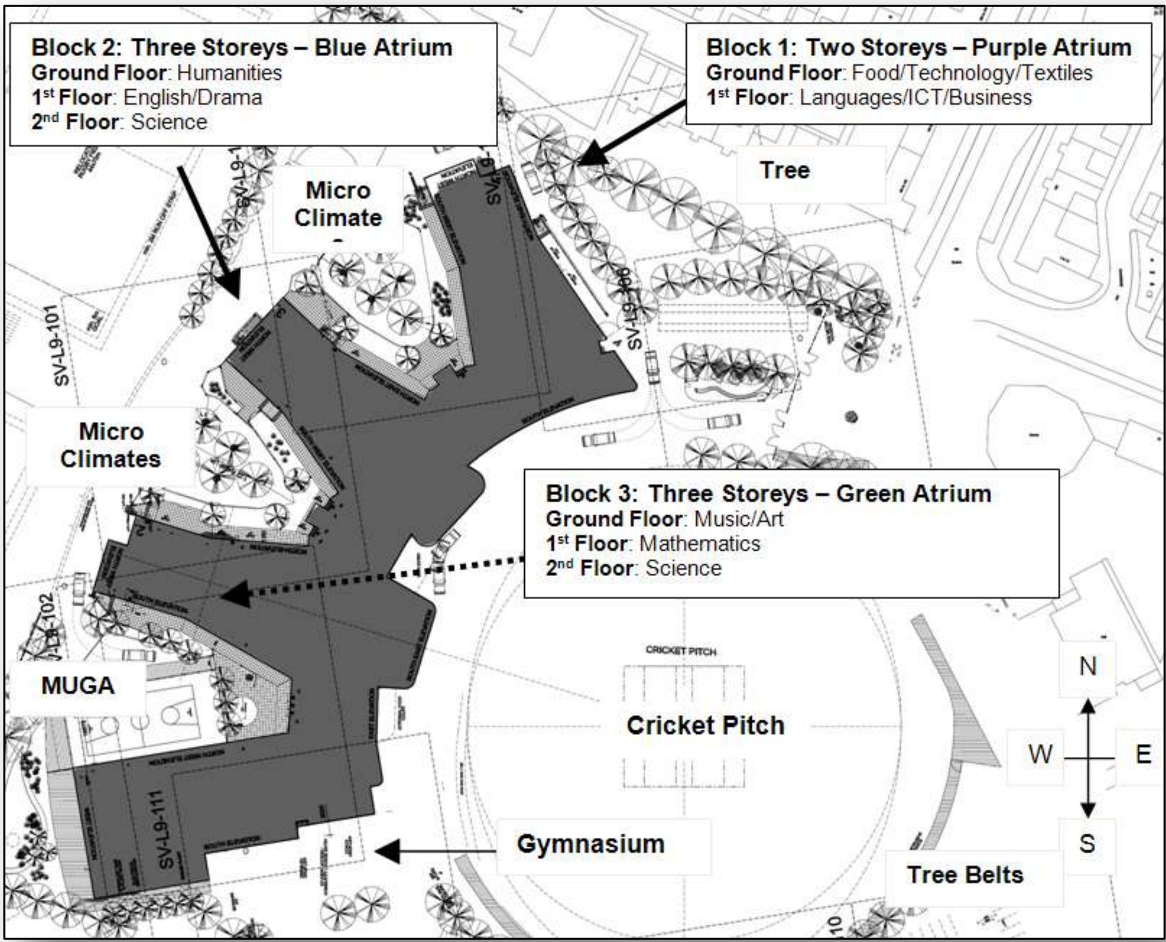


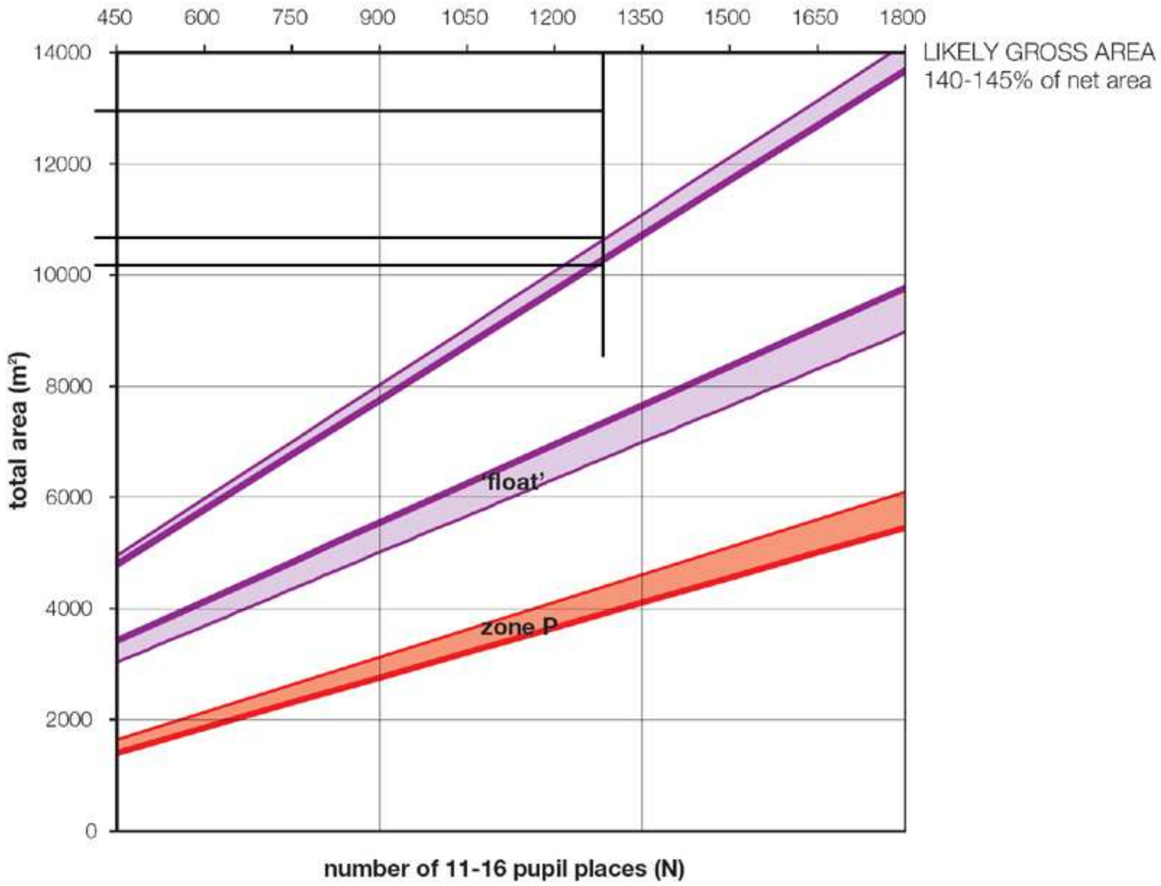
Figure 26. School B Floor Plan

With School B's external landscaping nominated for 'The most inspirational use of outside space', the design team's initial planning statement describes the campus as follows,

> "*Positive external landscaping, with the reinforcement of tree belts increases shelter from the wind (the site is relatively exposed)... the adjacent brook has been reclaimed by the school to act as a landscape feature **[C]** as well as a learning device **[A]**... the close relationship of the faculty teaching wings **[D]** with the surrounding landscape allows for external teaching **[A]**. Zones are provided where different curriculum areas could be extended to the outdoors to create science gardens, sculpture parks, ecological planting areas and general teaching spaces in summer. This will help to reinforce the principle of pupil participation and input in the design and development of these spaces" (Arc 2)*

Indeed, whilst it was evident from the above statement that the ecological and educational perspectives should be sensitively aligned, the physical size of the building raises questions about energy efficiency and how pupil numbers should determine a building's total floor space (m²). Of particular interest was the graph below which demonstrates how School B was approximately 25% larger than the recommended guidelines based on total pupil numbers. Interestingly, this same disparity was in evidence across all three new build projects.

Figure 27. School B: Pupil Number (1300) Vs Floor Area (13,300m²)



(Source: Part C, BB98, p.26)

Table 16. Guidelines: Pupils Vs Floor Area

New Build School	Floor Area (m²)	Pupil Numbers	BB98 Floor Area	% Difference
School A	10,500	1000	8,000~	25% larger
School C	12,000	1200	9,500~	25% larger
School B	13,300	1300	10,500~	25% larger

Looking at the black lines on figure 29 which relate to School B, the recommended floor area of a new build school should have been between 10,000m² to 11,000m². As it was, School B had a floor space of 13,300m². From an engineering perspective, the bigger the building, the more lighting and heating will be required.

At School C and B however, a lot of this space was devoted to the open plan corridor design which of course requires heating and lighting. At School A, whilst the corridors were not narrow, the streamlined design made sure the extra floor space positively supported the teaching requirement. However, these guidelines did not consider the actual physical footprint, i.e. the amount of land required.

Under the circumstances, the open plan designs at School B and C may have negative implications both in terms of the educational **[A]** and environmental **[C]** dimensions of the sustainable schools matrix. Evidently, the decision **[D2]** to extend a building's floor space beyond guideline targets needs to be linked to specific requirements and desirable outcomes.

Importantly, the Business Manager at School B emphasised how the decision to install internal CCTV **[D]** at cost of £30,000 **[E]** was a worthwhile investment which the school financed themselves as a result of value-engineering decisions. In one incident, a student had thrown a chair over the balcony from the third floor almost hitting a student on the ground floor. This student was later identified using CCTV and expelled **[B]**.

NB. With attainment and behaviour intrinsically linked, would it not be sensible for all schools to install internal CCTV? Moreover, Ofsted would then be able to inspect random video footage of classes without the need to inspect a school. Students would also know their behaviour would be objectively and independently inspected if an incident was to arise.

Looking next at the "active" components of the building, the original brief (output specification) included solar hot water, PV panels, a wind turbine, a biomass boiler and finally a dedicated energy centre to monitor the building's energy consumption.

However, due to financial restraints **[E]** imposed across phase one after the decision had been taken to rebuilding School A (originally identified as refurbishment project), these additional features were scaled back in favour of a standard biomass system at School B. Indeed, whilst a small array of PV panels have been installed, their contribution was nominal, existing mostly for educational purposes **[A]**.

The list below summarises the building's main components **[D]**.

- The biomass system consists of a single 500kW Hertz LPHW boiler.
- To provide additional heat, two gas-fired LPHW boilers were installed, each with a capacity rating of 531kW.
- Internal temperature control was delivered through under-floor heating and air handling units by pumping hot water around the building.
- There was no active (air-con) cooling system designed into the HVAC system.
- 21 air conditioning units rated at 3kW were located around the building where overheating would be required (ICT rooms, dance studio and fitness suite etc).
- The mechanical ventilation was delivered via ductwork and controlled by air handling units. Fans used variable speed controls to manage this process.
- There is a night purge program in operation to reduce internal temperatures.
- Hot water was delivered throughout the building, including the gymnasium using the primary gas boilers. The hot water is then stored in local hot water calorifiers (tanks).
- The solar hot water and the solar PV systems were not properly commissioned.

In summary, School B was an ambitious project that set out to create a spacious environment using an original layout configuration. A lack of natural daylight in the open plan corridor areas was a notable failing. There was also evidence to suggest the biomass system was not operating at full capacity. Furthermore, due to a combination of both overheating and poor air quality, it was assumed that the under-floor heating and HVAC systems were not working correctly.

Under the circumstances, the added size and complexity of the two PFI schools tends to suggest an extended commissioning period **[D2]** would be required. However, with a project deadline set in advance, it would seem there was insufficient time to properly commission the two buildings prior to the official occupation in September 2009.

In the chapters which follow, a more detailed examination of the commissioning has been considered.

5.3 School C

Image 6. School C

Designed by the same architects (1) and engineers which developed School A School C was funded using BSF-PFI credits as opposed to conventional finance which accompanies Design and Building contracts **[E]**. In terms of capacity, the new building was designed to accommodate 1,200 pupils between the ages of 11 to 16 **[A1]**. The researcher did note however that estimates for total project cost varied from £16m to £20m but now believes the amount was closer to £20m **[E1].**

In their summary of the previous structure the architect's report confirms how the existing 1970s CLASP[18] building was no longer fit-for-purpose **[D]**,

> "*It is in poor condition and of little value. Accessibility is very poor with many areas being inaccessible to a wheelchair user. Throughout the school there are numerous changes in*

[18] The CLASP (Consortium of Local Authorities Special Programme) system was a scheme developed in the 1950s by English local authorities to devise a method of designing and assembling prefabricated buildings for use in the public sector. (Source: http://en.wikipedia.org/wiki/CLASP_(British_Rail))

> *level that are worn out due to age. The fabric of the original building is in poor condition and thermally ineffective..." (Arch 1)*

The total floor area was 7,724m² consisting of 65 classrooms spread over 3 storeys. By contrast, the new building had a floor space of 12,000m². In the old building, a lack of natural light in corridors was an issue which emerged from the design team's consultation with the school. ICT resources in the old school were also limited to a single dedicated computer room with no external windows. As a result, ICT **[D]** played a minimal role in the education process **[A2]**.

In the new building ICT was available throughout, providing staff with 57 interactive whiteboards and 550 computers and laptops **[D]**. The online services, delivered by the ICT supplier provided the benefits described previously at School A – cashless transactions and automated student registration (morning and afternoon).

Situated in what the architects describe as a "mixed community with significant areas of deprivation" **[B]**, security was an important factor in the design process at School C. In the health and safety documentation the architects highlight the involvement of the police architectural liaison officer. Regrettably, as the business manager explained in an interview, the building has since been the victim of several burglaries **[B]**. As a result, the external security lighting was altered to remain on throughout the night **[D]** which increased the electricity consumption **[C]**. Following these unfortunately incidents, the business manager expressed regret when reflecting on the decision not to install a secure perimeter steel fence. However, it is evident from the original planning statement how the school and the design team were keen to create a more community centred facility **[B]**.

> "*Creating spaces where the users can take 'ownership' is important in preventing vandalism and encouraging pupils and people within the community to look after 'their' school. The more that the school environment responds to its user needs the more attractive it will be to its legitimate users and the less attractive it will be to the criminal minority... Physical barriers such as thick hedges around the site cartilage are well defined and resist access" (Arch 1)*

At the same time, the designers were evidently mindful of the desire to create a safe environment that would protect staff and students from outside threats. Evidently, finding a solution which incorporates effective security with a welcoming external design has potential implications for the way buildings engage with the wider community. Indeed, with the ecological report emphasizing the abundance of local wildlife on the 65 acre semi-rural site **[C]**, with many children living in relatively poor urbanized communities **[C]**, the new building's design and orientation took full advantage of the surrounding wildlife by incorporating large glass windows **[D]** throughout the communal areas.

The relatively exposed location would also enable the design team to consider how best to exploit the prevailing wind conditions as part of a more innovative and sustainable design philosophy.

> "*This semi-rural site is quiet and should experience good air quality and wind speeds. It is therefore ideal for natural ventilation of buildings. A mixed mode ventilation solution **[D]** is proposed for best internal environmental conditions, coupled with lowest energy." (Arch 1)*

Indeed, when the council was initially exploring their options with regards to their 10% onsite renewables policy, a large 200kW wind turbine was mooted but swiftly rejected by the planning department. BREEAM compliance was also a factor which resulted in the decision to select biomass **[D]** as a low-carbon alternative to a conventional gas heating system.

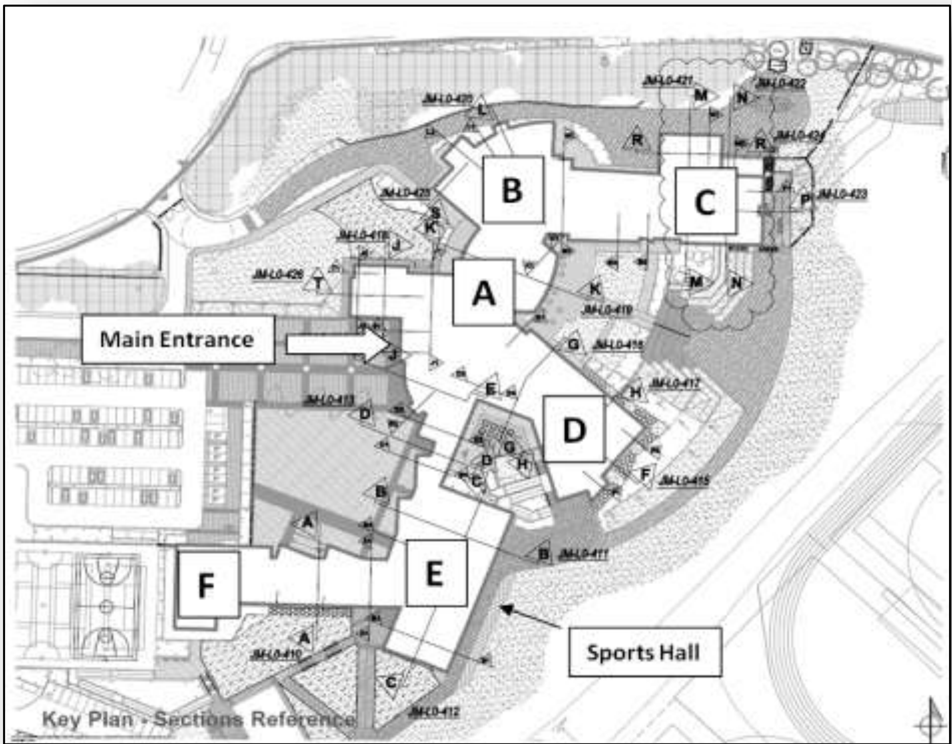


Figure 28. School C Floor Plan

In terms of the actual construction, School C was built using the same methods and materials as School A The structure's central core is based around a steel frame with concrete floors. The outside of the building consists of brickwork, render, aluminium windows and a steel roof **[D]**.

The entrance area, library and dining room (Block A) area is double height single storey with a total floor space of 940m².

Blocks B and C are the two storey teaching areas with a floor space of 3,620m².

Block D is a 3 storey 1,950m² teaching block which benefits from natural light from the roof and the external windows (image 6). In addition the open plan corridors provide tables and chairs for flexible learning (image 6).

Image 7. School C Block A

Image 8. School C, Block D

The gymnasium (Block E) facilities have a floor space of 1,200m². Block F was another two storey teaching block that had a total floor area of 3,600m². Indeed, the layout of the building appeared to have the largest land "footprint" of the four schools**.**

It was therefore interesting to note how the architects describe the design and layout as a,

> " *... dynamic combination of teaching 'wings' projecting out from a hub with the social and dining spaces at the core. The teaching wings are clusters of facilities arranged on different floors around faculty resource areas" (Arch 1)*

To enhance the internal environment, glazed walling was used throughout the social and dining areas. Indeed, the architects confirm how the building's footprint was rotated slightly to maximise the scenic views out into the local countryside. Indeed, when the school's head teacher was invited to comment about his interpretation of BSF's "educational transformation agenda", he explained how the new physical building creates aspiration **[B]**, and the open plan design **[D]** complemented by the large expanse of south east facing glass creates an attractive and calming environment which both the staff and students can benefit from.

Image 9. School C, Dinning and Social Space [A and B]

The figure below provides a comparison between the old and the new building, whilst identifying the 500m² language block (G) which was built in 2004.

Figure 29. Old building plan versus New Building Plan

Interestingly, when the researcher was discussing the design process with a governor during a visit to the school, whilst the head teacher was committed to his aesthetical vision, the comments below demonstrate a more complex picture relating to energy efficiency,

> "*... there was nothing we could do to influence the detail... they [the builders] said... "it has all got to fit with the other schools" ... if we could make the builders responsible for lighting and heating* ***[D2]****... as well as maintaining it... then they've got an incentive to invest* ***[E]*** *in energy saving* ***[C]*** *now... in some of the corridors you could have had light pipes coming in or you could have had a glass floor... but the designers said "We knew we could do this and achieve BREEAM excellent so we didn't suggest any radical solutions"... so I think it is the City Council who needs to set the high standards" (Governor, School C, Site Visit, 2010)*

Interestingly, the Head Teacher's exemplary commitment to the participatory phase of the design process was demonstrated by his comments below **[B2]**,

> "... *we sent all the staff to any school they wanted to go to... they had to write it up and discuss it on the internet... we began 5 years ago... I must have spent thousands and thousands of hours doing things to do with everything from teaching and learning, all about the vision and that kind of thing, right down to ceiling tiles..." (Head Teacher, Site Visit, 2010)*

> "... *Make the staff own it! The architects would show us something and we'd say no go back and change that, move it to here, they came back from an engineering view about air flow and we said "no", we want x, y and z ... we had a cost envelope of £19.5m* ***[E1]*** *we had to stay within and we had a space envelope* ***[C1]*** *we had to stay within so there were a lot of compromises... we could have had narrower corridors and gone for bigger sized classrooms but... this is so easy to supervise" (Head Teacher, Site Visit, 2010)*

Furthermore, with the need to comply with building regulations (2002) and BSF guidelines the thermal performance of the building's external envelope has been presented on the table below.

Table 17. School C, External Envelope Comparisons

External Surface	L2A (2002)	School C	% Improvement
Walls	0.35	0.26	26%
Floor	0.25	0.25	0%
Windows	2.2	1.8	18%
Roof	0.25	0.16	36%

Source: Engineering Firm

Indeed with the walls and roof exceeding the BSF guidelines, King-Span, the company responsible for providing the insulation materials, explain in their documentation how,

> "... *the embodied environmental impacts of all of the materials and labour used to create a building are insignificant in comparison with the lifetime operational environmental impacts of that building... saving energy by specifying the lowest U-values possibly is the most environmentally sustainable action to take..." (King-Span, Sustainability Statement)*

Looking finally at the "active" components **[D]** of the building, Gifford provides the following information in their documentation which links together the aims and objectives with their proposed design solution.

Efficient construction – a design than can be built with the minimum of waste from the most sustainable materials
Energy – A complete building and site design that minimises the use of fossil fuel energy and makes a significant contribution to its own energy needs from low or zero CO_2 technologies.
Transportation – a site layout and design that promotes sustainable access by walking, cycling and public transport, thereby ensuring that the school sites have minimal environmental impact wherever possible.

- In mechanically ventilated spaces, a maximum CO_2 concentration of 800ppm.
- In naturally ventilated spaces, a maximum CO_2 concentration of 1500ppm.
- In mechanically cooled spaces, a maximum internal air temperature of 25°C.
- In all other teaching spaces, a maximum of 30 hours over 28°C per year.
- An average daylight factor of 4% or more in all teaching spaces.
- An average daylight factor of 2% or more in all circulation spaces.

Gifford also describe how they intend to reduce energy consumption across the four schools as part of phase one's "portfolio" strategy.

> "*The school has an aspiration that the submitted design should be carbon neutral, which is an extension of the requirement to deliver 10% CO_2 saving by onsite renewable energy generation. All four schools have a 10% CO_2 reduction requirement, which it is proposed are aggregated onto the School C site. Because of the existing supply infrastructure in the Leicester area, and as a result of cost-benefit analysis* ***[E-D]****, biomass heat supply has been selected as the most cost effective method of achieving the 10% CO_2 reduction. Biomass unitary costs decrease with size, hence the most economic way of saving 10% CO_2 across all four sites is to supply approximately 40% saving to School C using biomass. This equates to around 70% of annual heat energy supplied by biomass, with a gas backup system. We would propose to supply in excess of 90% of the annual heat energy using biomass, to move towards carbon neutral status for the school." (Engineering Firm, Part 1, General Information).*

The list below details the building's major components **[D].**

- The biomass system consisted of two LPHW boilers delivering a total capacity of 530kW.
- To provide additional heat, two gas-fired low-pressure-hot-water (LPHW) boilers, each rated at 250kW, were installed as back-up.
- Temperature control was delivered through under-floor heating and air handling units by pumping hot water around the building.
- There was no "active" cooling system designed into the HVAC system.
- There is a night purge program in operation to reduce internal temperature.
- Mechanical ventilation was delivered to classrooms via ductwork and AHUs.
- Air conditioning units have been installed in dedicated areas of the building.
- Hot water was delivered throughout building via the main boiler system with two specific calorifiers (hot water tanks) feeding the main building and the gymnasium .
- The lighting system mainly consists of linear fluorescent T5 strip bulbs, controlled by passive infra red (PIR) sensors that detect movement.

To what extent the larger budget facilitated a low-energy solution is not clear. It has therefore been necessary to examine energy performance post-occupancy in order to clarify this issue. Evidently, School C was a larger more sophisticated building than School A.

5.4 School D

Image 10. School D

As part of the initial ‘competitive bidding’ process to select the preferred bid team, phase one was required to include at least one refurbishment project. As a result, School D was identified and financed and procured using a standard ‘Design and Build’ contract.

School D is a mixed comprehensive school catering for students aged 11 to 16. In 2003 a gymnasium was built at a cost of £1.5m. Constructed by Hallam Contracts and designed by KPW Architects, the gymnasium has its own DEC certificate and separate BMS metering system.

Originally built in 1935 to accommodate Newark girls’ grammar school, the building was designed to accommodate 450 pupils. The former head teacher who oversaw the redevelopment of School D described the old building as,

> “... *cramped... the corridors and stairwells were restricted, and although some of the classrooms were bigger than are required, some were significantly smaller. Opportunities for small group work or personalised curriculum were just not available.”*

This refurbishment project was made more complicated by the fact that the school continued to use the building throughout the construction period when temporary classrooms were erected to provide additional accommodation. During this time, the project overran its original 115 week schedule to 140 weeks. However, it was the effort during the design phase which the head teacher felt made all the difference,

> "*The [original] plans did not meet our educational vision... this is a school facing challenging circumstances: we wanted to do something quite transformational" (Former Head Teacher)*

Image 11. School D Clock Tower

The actual (land) "footprint" of the new building was relatively small compared with the three new build schools. However in terms of indoor floor space, the three storey extension substantially increased the available space to approximately 10,250m². In total the project cost in the region of £12m **[E1]**.

As far as the original structure was concerned, the south east facing entrance and clock tower were preserved as the picture to the above illustrates.

Where the old hall previously stood behind this attractive frontage, a new central teaching block was created. In the old building, the corridors were said to be dark and narrow. In the new section of the building, the central atrium walkway benefitted from extensive natural light from the glass roof.

Furthermore, the building's natural ventilation solution was based on the "stack effect" system **[D]** where cool air enters the building from external windows, passes through the classrooms and office spaces towards the central atrium. At this point, the warm air rises towards the glass roof where vents controlled by the BMS system open to allow the hot air to escape.

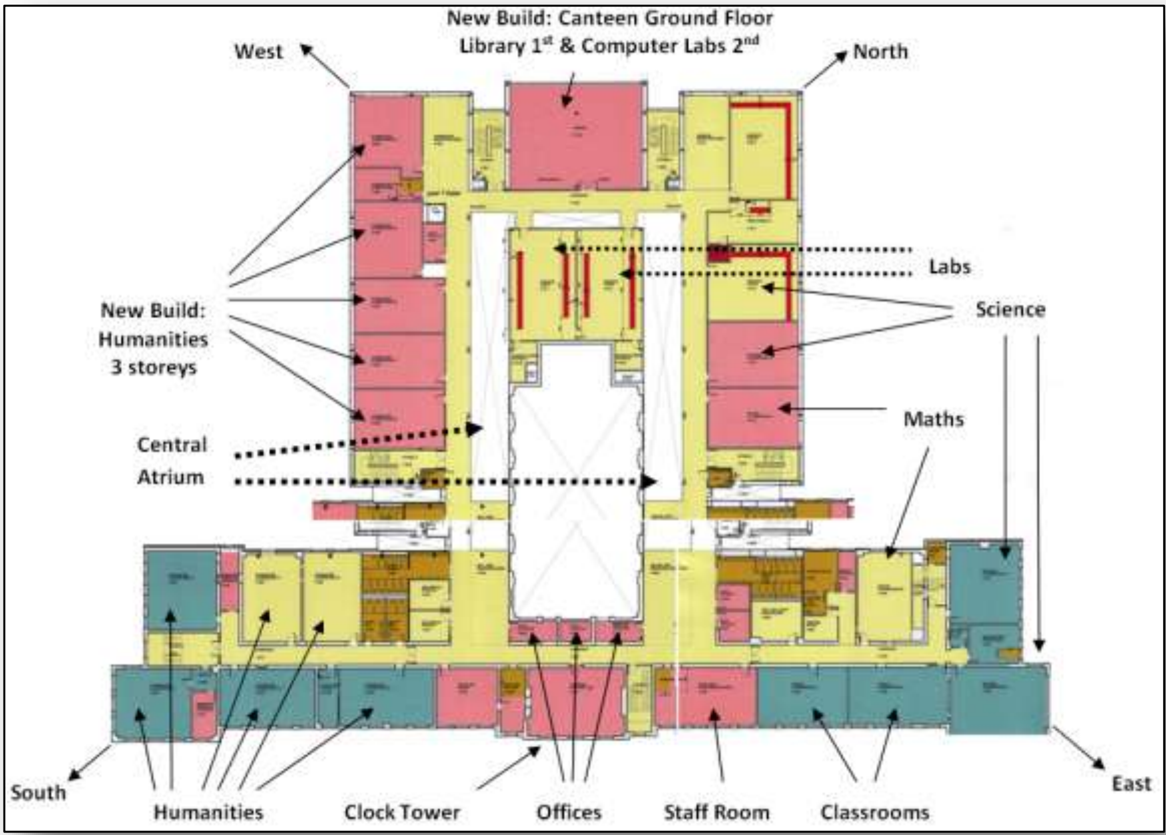


Figure 30. School D Floor Plan

The new section of the building includes a dining area, science laboratories, ICT rooms, library, and standard size classrooms. The new block was arranged over three floors along two parallel walkways.

The Head teacher articulated his vision as follows,

"*The school design integrates the tradition of our historic building with modern architecture. For School D, BSF will put the school at the heart of the community and give people a focal point for high quality education".*

Since the refurbishment all the windows through the existing building were replaced with double glazed units. The building's

Figure 31. School D Walkway/Atrium

ICT provision also now contains 310 PCs, 190 Laptops and 30 interactive white boards **[D],** placing greater demands on the building's natural ventilation and cooling systems **[D]**. Moreover, with the building's orientation predetermined by the existing structure, shading from solar radiation was a concern which the design team would be required to address. Indeed, when the researcher was informed how external shading had been removed from the original specification, it was unclear from the documentary evidence how the existing natural ventilation strategy would cope on its own. Indeed, since there was no alteration to the HVAC system to include a properly integrated cooling strategy, supplementary air-conditioning units were installed in areas where overheating could be expected.

Looking next at the thermal performance of the building's envelope, with refurbishment BSF projects only requiring a BREEAM design quality score of 'very good' (>50), it was noted how the specified U-values were still 20% better than the 2002 building regulations (except the floor).

Table 18. School D External Envelope

External Surface	L2A (2002)	School D	% Improvement
Walls	0.35	0.28	20
Floor	0.25	0.25	0
Windows	2.2	1.75	20
Roof	0.25	0.2	20

Source: Engineering Firm

To what extent these figures reflect the performance of the new build section as well as the refurbishment was not made clear from the architectural documentation. However, by comparing the gas consumption at School D with School A, a better appreciation of actual thermal efficiency can be obtained given that both schools are exposed to the same climate conditions.

From a design perspective, the building's main features have been listed below.

- The main plant room contained 3 Low Pressure Hot Water (LPHW) boilers each rated at 372kW using natural gas.
- The heating system was delivered through a combination of duct work and Air Handling Units in the new build section and conventional radiators set to 21°C in the refurbished section.

- Domestic Hot Water is provided by the main boiler plant and pumps. There was no separate gas-fired calorifiers (hot water tanks) installed.

- There is no mechanical cooling system built into the HVAC system. Instead, dedicated air-conditioning units were installed throughout the building activating only when the set temperature of 23°C was exceeded.
  - Server Room x2 ac units operating 24-7.
  - Three ICT Rooms x6 operating during occupancy hours only.
  - Reprographics Room x1 operating during occupancy hours only.
  - Dance Studio x1 operating during occupancy hours only.

- The lighting system mainly consists of linear fluorescent T5 strip bulbs, with Passive Infrared (PIR) detection controls which activate when there is movement.

In summary, all four schools were conventional in terms of their construction (concrete floors, steel frames etc). Air tightness tests and examination of the building materials demonstrate conformity with the prevailing building standards[19] underpinning phase one **[D].**

It is also important to acknowledge how the contractor was able to finish all four schools on time **[A/B]** and on budget **[E]**. However, due to the minimal weighting of energy efficiency as part of the procurement and design phase, apart from the contractual obligation to satisfy the BREEAM requirement, opportunities to create more sustainable and innovation solutions were limited. As a result, the design solutions were shaped by a conformance strategy, relying on minimum standards set out by the regulatory framework as the primary driver in the design process. However, it is also true that financial restrictions played a major role in determining the type of buildings to be constructed.

Crucially, by developing the Sustainable Schools matrix, as the 5 Capitals model has previously explained, the avoidance of trade-offs can be achieved if practitioners and policy makers recognised the integrated nature of a system from the beginning. This is particularly important for improving the way successive waves of schools are procured, designed, constructed and subsequently managed post-occupancy as demonstrated by the BSF programme. There is also a need to (financially) incentivise developers to aim beyond minimum standards.

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[19] Target: 10m³/m²/per hour – see Appendix B for actual reports.

Chapter 6 Post-Occupancy Evaluation

This chapter focuses mostly on the observed (qual) and recorded (quant) outcomes following the occupation of the new buildings in September 2009. As a result, the analysis takes on a more comparative style, allowing the four schools to be judged side by side as part of a mixed-methods, multiple embedded, case study analysis.

6.1 Energy Analysis (2009 - 2010)

6.1.1 Leicester City Council

During the first 12 to 18 months of the study, it was important to establish how much energy the schools were actually using. During this period the researcher familiarised himself with the various benchmark figures and government initiatives designed to promote energy efficiency. New schools were expected to achieve an Environmental Performance Index (EPI) score of 40KgCO$_2$/m^2/yr according to CIBSE (2008). In addition, a number of phase 2 projects were now benefitting from extra funding **[E]** in order to achieve the more stringent target of 28KgCO$_2$/m^2/yr. A further £50/m^2, equivalent to approximately £500,000 per project **[E]**, would be made available to achieve the necessary efficiency savings**.**

With the researcher electing to spend one afternoon per week working at the council offices, he was able to establish a relationship with their energy team. Leicester City Council's data analyst, initially presented the researcher with the first year of monthly utility data. From this one data set it was then possible to carry out a series of calculations which can be summarised in the following stages,

1. Convert raw data (kWh) into tonnes of CO_2
2. Normalise raw data (kWh) based total floor areas (kWh/m^2)
3. Calculate EPI scores (Kg CO_2/m^2) for each school based on the first year data
4. Calculate annual costs using the FM/Council tariffs for Gas and Electricity

On the following page each stage has been presented.

A = Education; B = Community; C = Environment; D = Technology; E = Economics

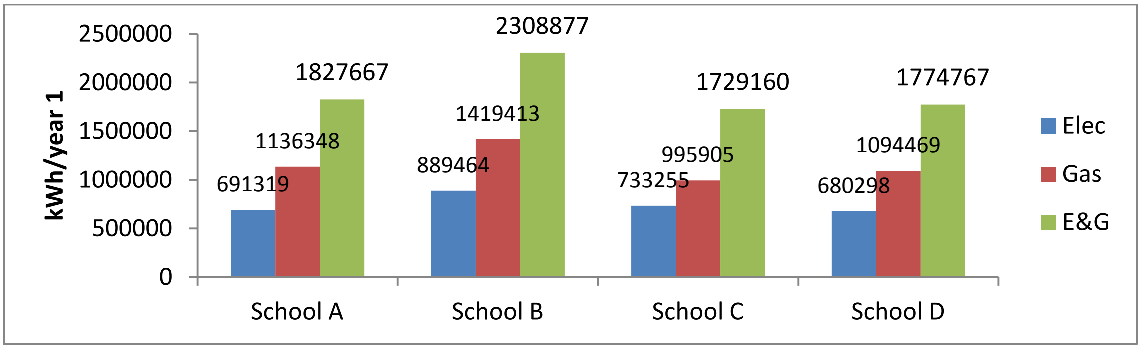

Figure 32. Total kilowatt hours (kWh) Year 1

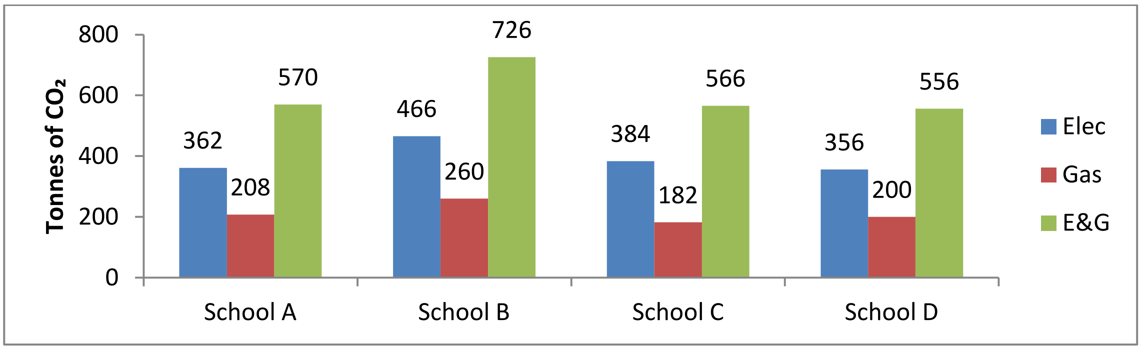

Figure 33. Tonnes of CO_2 Year 1

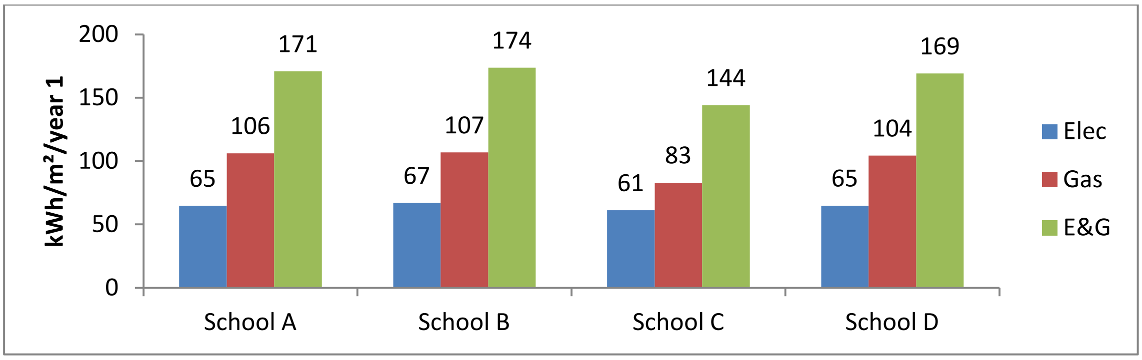

Figure 34. Normalised Data (kWh/m²) Year 1

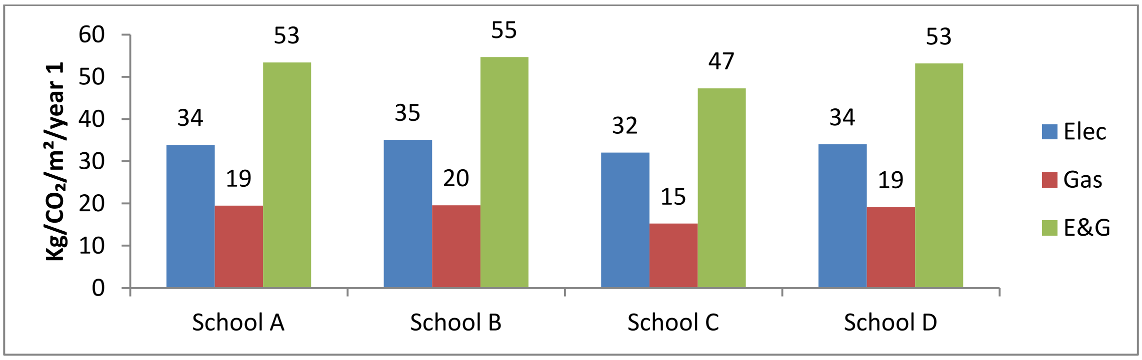

Figure 35. EPI (Kg/CO_2/m²) Scores Year 1

As these 4 contrasting bar charts illustrate, even basic monthly data can be used in various ways to underline the complexity of calculating energy and environmental performance in buildings.

Broadly speaking, gas makes up about 60% of the actually “energy” consumed (in kilowatt hours). However, in terms of the environmental impact, electricity is responsible for about 65% of the carbon emissions. Furthermore, based on these provisional results for year 1, on first inspection, School C appears to have the lightest carbon footprint, with a total EPI score of 47.

Converting this gas and electricity data into annual running costs was based on commercial rates obtained by the FM provider; electricity = £0.085 per kWh; and gas = £0.03 per kWh, which produces the following table.

Table 19. Year 1 Leicester City Council Utility Costs

	School A	School B	School C	School D
Electricity	£58,762	£75,604	£62,327	£75,604
Gas	£34,090	£42,582	£29,877	£32,834
Total	£92,852	£118,186	£ 92,204	£ 108,438

More generally, this analysis confirms how de-carbonising the supply of energy (the national grid), coupled with a reduction in end-use demand through technology advancements and behaviour change, will together help to achieve the government’s 80% reduction target by 2050**.**

Indeed, by grouping the four buildings together, it becomes more apparent how demand varies throughout the year. Moreover, as phase one adopted a “portfolio” strategy, the researcher calculates that 2,418 tonnes of CO_2, was emitted in the first year of operation across all 4 schools.

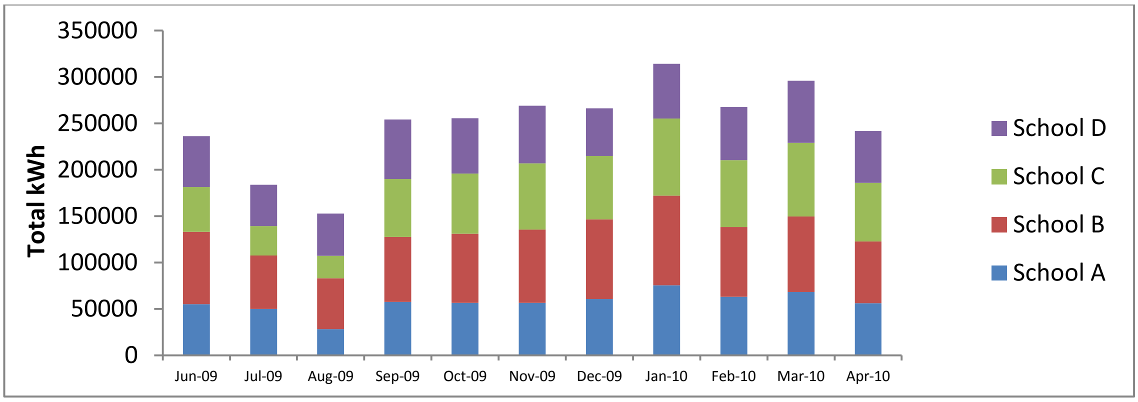

Figure 36. Phase One Electricity Demand Year 1

Seasonal gas consumption is noticeably more pronounced with consumption increasing by a factor of almost 10 during winter months. It was also noted how consumption appears to drop in January 2010, reflecting the minimal use over the Christmas holiday. Interestingly, the electricity data (figure 36) registers this effect one month later in February (2010).

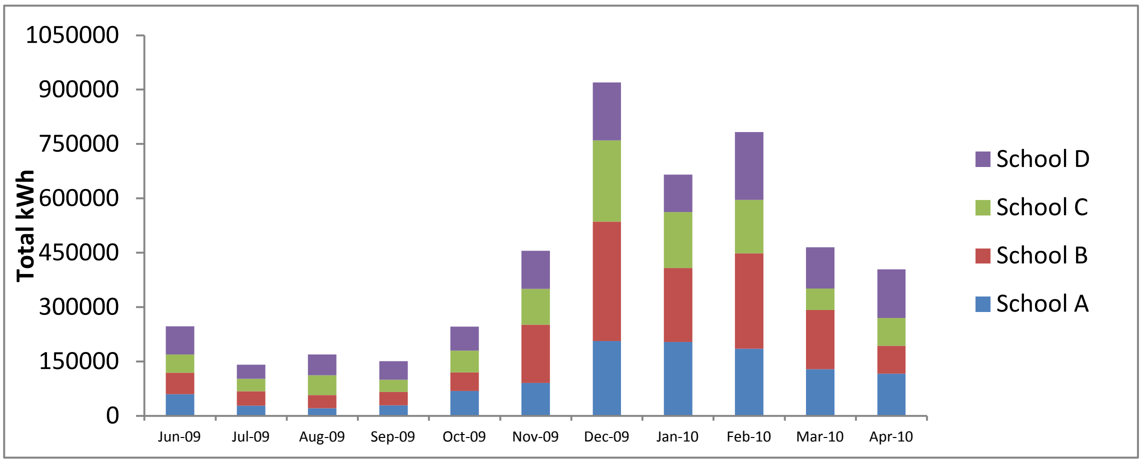

Figure 37. Phase One Gas Demand Year 1 [D3]

6.1.2 Facilities Management (FM) Provider

More recently, the unknown costs associated with FM contracts has created uncertainty about the long term implications of the BSF programme. These concerns were first aired by the Business Manager prior to the cancellation of the BSF programme in 2010.

> "*... the worry for the old schools is what the conservatives will do with the BSF programme. That will have a massive impact on phase 1 schools... because the FM service will not be as it was first thought it would be where there would be deduction in costs as more schools come online" (Business Manager, School C, 25th May '10).*

To complicate matters, Leicester City Council were concerned about the technical competence of FM staff working onsite,

> "*... The FM contractor has only just captured the temperature sensor data.... They [the FM team] have not taken control of the CO2 sensors. There needs to be night time ventilation. We've struggled to get the FM company to be pro-active about it" (LCC, 2010)*

With these issues in mind, the researcher contacted the FM provider to request any documentation they may have about the performance of the four schools. After some time, the researcher received an ‘Energy Management’ report, published in July 2010 by the FM team’s energy analyst. Whilst most of the information related to the monthly utility readings, the report did contain four graphs which examine the heating systems using outside temperature data (aka ‘degree-day’ regression analysis). This technique **[D2]** helps to determine how responsive the heating systems behave, which in turn provides a basic indication about efficiency.

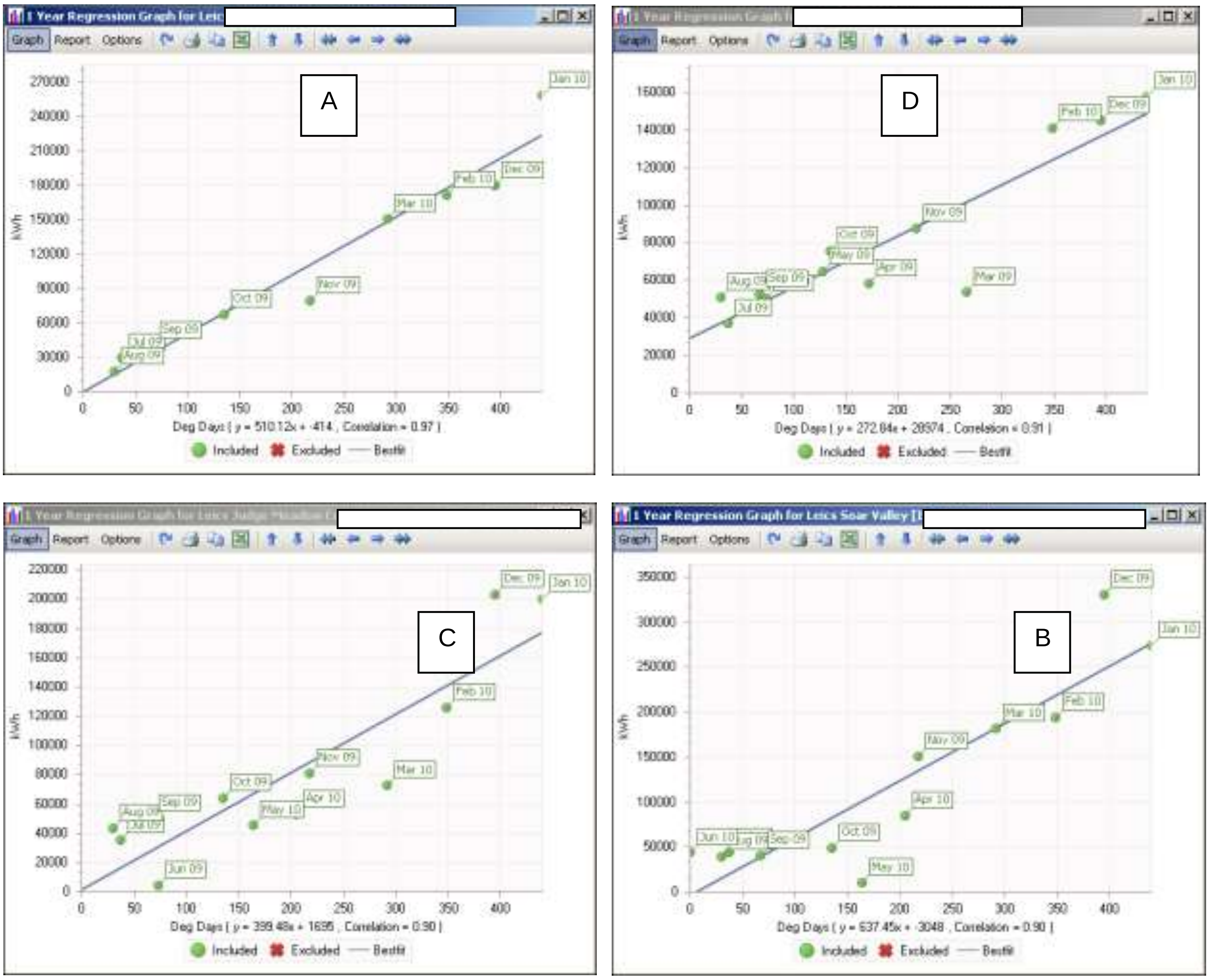

Figure 38. FM Provider: Degree Day Analysis

Early indications suggest School A had the most efficient heating system, producing a correlation score of 0.97 **[D]**. By contrast, the other three schools had correlation scores of 0.90 which the FM provider interprets as follows,

> "*... this shows reasonable correlation, indicating a satisfactory level of control of the heating systems*, *with the possibility for further improvement and energy savings."*

At this point in time, with only manual meter readings available, there was no detailed analysis of each building's energy performance. In this regard, because the buildings were experiencing operational problems, the delay in fixing the monitoring systems gave rise to the suspicion that operational performance was far greater than predicted.

> *"... may be the FM team are reluctant to give it [the data] to us, because we are asking these particular questions about energy consumption, this is where I am hoping this meeting will lead us down a path way that the FM provider don't feel they need to hide these figures... that we are all here as a partnership to reduce energy… but sometimes I do wonder whether the FM provider are aiming to reduce energy or whether they are just happy to go along so long as they don't exceed 100%." (JM Business Manager, 25th May 2010)*

6.1.3 Half Hourly Electricity Analysis (Year 1)

With no reliable high-resolution data forthcoming from the FM provider, and with the online database out of action, the council requested that Eon, the utility company, send them half-hourly data. When eventually electricity data was made available, the council's energy analyst produced a report. Indeed, whilst this analysis was relatively simple in terms of statistical analysis, it was possible to identify instances where system malfunction **[D]** gave rise to unnecessary electricity consumption.

The first example looks at School A. Here it was discovered how standby consumption appears to increase during specific weeks throughout 2009 and 2010. The second example which looks at School B identifies even more disruption where standby consumption appears to remain high for extended periods of time. In both cases, the analysis assumes equipment was left on by mistake, giving rise to increased standby/base-load consumption.

It was evident to the researcher that a more detailed analysis would be required. It was at this stage that the researcher utilised a specialist software package developed by Dr. Kilpatrick (see p.95 in methodology chapter for more information).

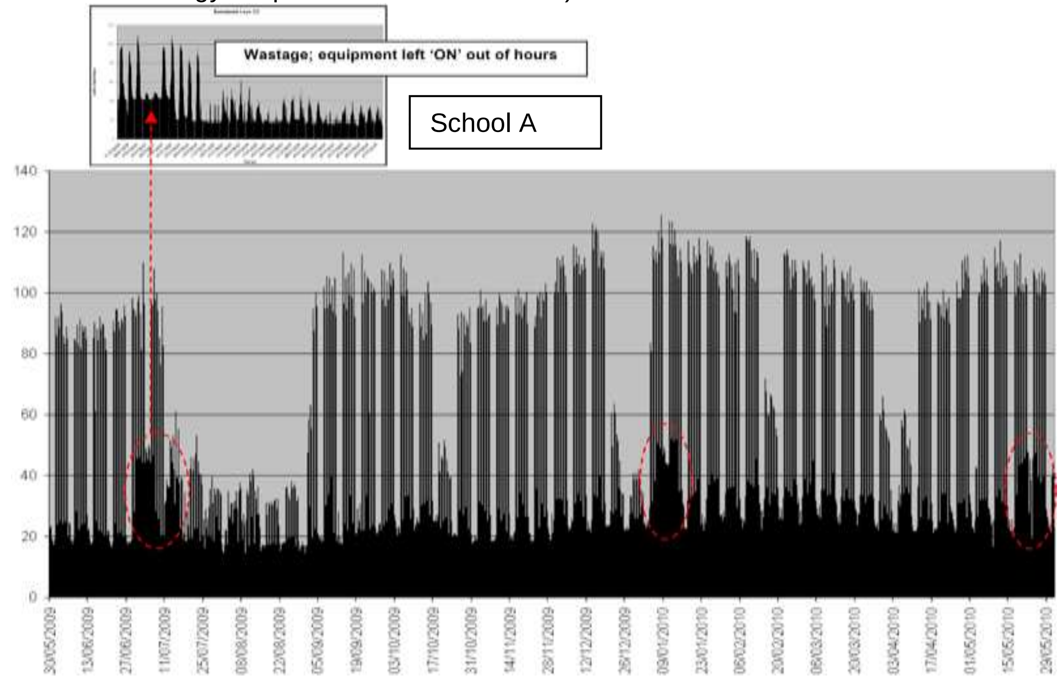

Figure 40. LCC Half Hourly Analysis

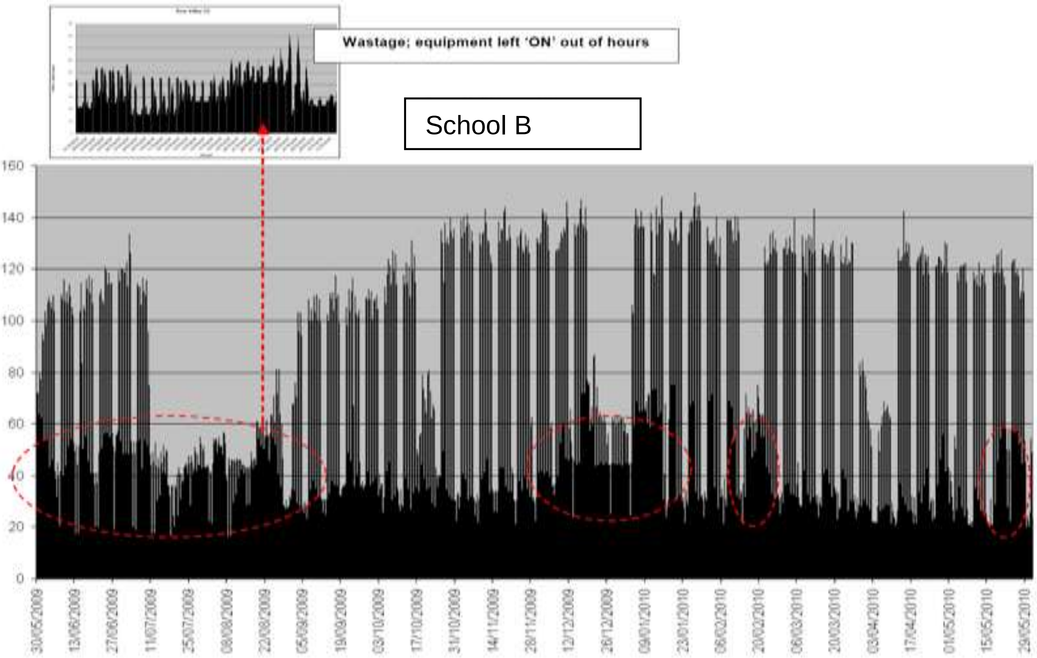

Figure 39. LCC Half Hourly Analysis

Using the first 12 months of half hourly electricity data, this program was able accept all four sets of data for each school to produce figure 41.

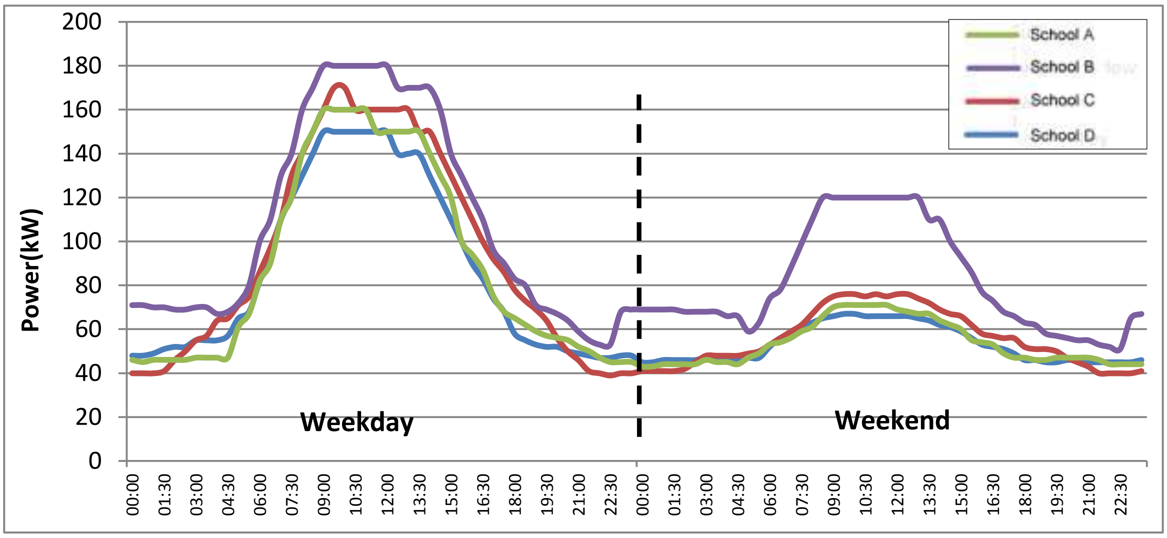

Figure 41. Power Profiles Year 1 (Courtesy of R. Kilpatrick)

This graph illustrates the average yearly profiles for each school. On the left hand side, all 260 weekdays are averaged out to produce the Monday to Friday average profile. On the right hand side, 105 days are used to produce the average weekend profile. It was important to recognise however that school holidays have not been removed from this data set.

The first thing to note is the similar shape of all four schools during the week days. This indicates that the four buildings have very similar electricity requirements. At approximately 4am the demand for electricity begins to increase, rising to a maximum power of 160kW at around 9am. It is also worth noting that the heating systems rely on electricity to power the pumps and fans during the morning 'start-up' period.

Peak load continues for about 4 hours through to 1pm, after which point demand for electricity slowly decreases until standby power (~50 kW, base-load) is reached at around 10:30pm.

Looking at the subtleties of each schools' daily power profiles can reveal some interesting insights which may help to corroborate the instances of "waste" identified by the previous report by Leicester City Council. School B for example was a larger school with 1300 pupils in attendance. As a result, weekday peak-load was consistently higher than the other three schools. This does not explain however why the out-of-hours "standby" consumption would also be higher. It was further observed at School B how standby power appears to jump from around 50kW to 70kW at 10pm for no apparent reason. Could this be something to do with external lights switching on overnight as part of the building's security strategy?

At weekends, School B's power profile again exhibits the same jump in electricity at 10pm. More significantly however, consumption from 5am to 6pm is far greater (over the weekend) than any of the other three schools. Why this occurs demands further investigation!

More generally, all four schools during the week (Monday to Friday) power down at a similar rate. This tends to suggest the schools were not used extensively beyond 3.30pm. However, in order to properly investigate this assumption it would be sensible to look at average profiles for each day of the week and follow this up by examining each school's particular weekly schedule of activities.

Taking into account each schools' total floor space, the programme was then able to calculate the "normalised" performance to reveal a more nuanced picture.

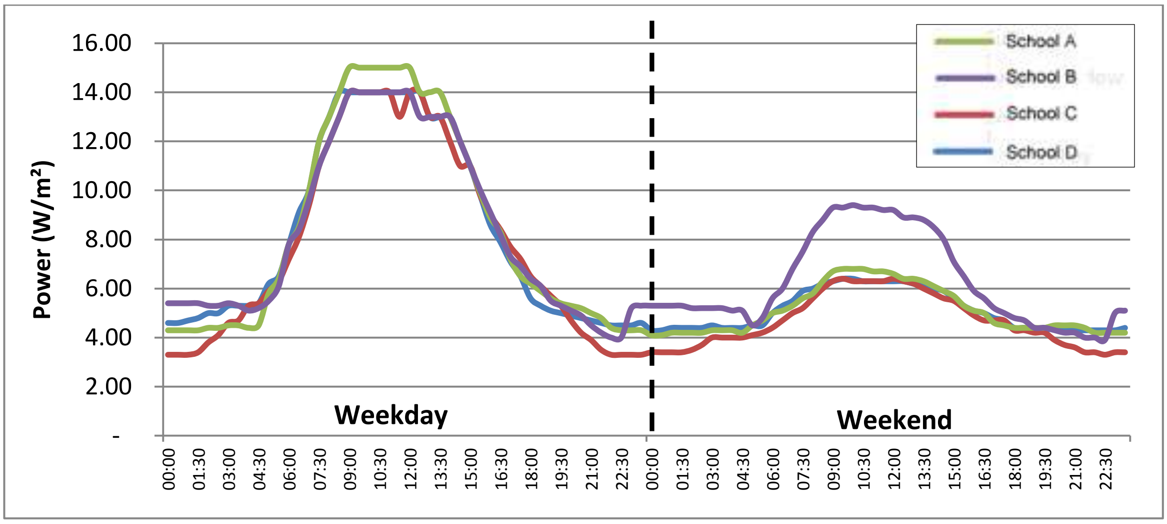

Figure 42. Normalised Power Profiles Year 1 (Courtesy of R. Kilpatrick)

Looking at figure 42, variation between the weekday profiles has now reduced, illustrating the similarity in energy efficiency between the four schools. Indeed, whilst standby power for all four schools hovers between 4 to 5 W/m², it was interesting to note how School A had the highest peak load demand at 15W/m². Furthermore, this normalisation process helps to confirm how School B continues to exhibit a high base-load demand overnight.

Looking next at figure 43, School B's excessive weekend consumption has now been linked to the final three months in 2009. Thanks to the half-hourly data it was possible to isolate this period of excessive consumption **[D2]**. Moreover, when the researcher presented this information to the business manager at School B he was not aware of any reasons why this consumption should have occurred.

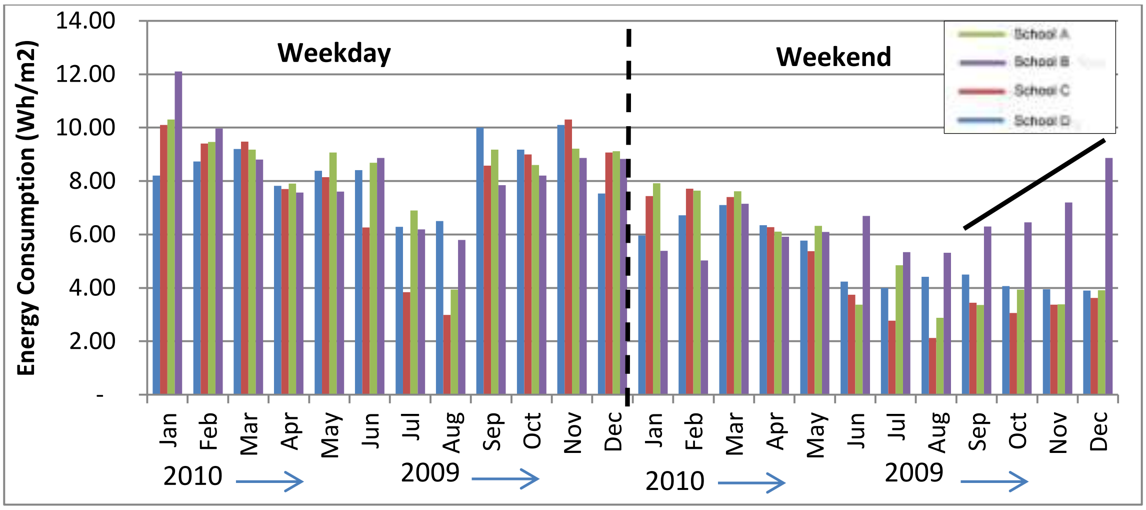

Figure 43. Monthly Normalised Electricity Consumption (Courtesy of R. Kilpatrick)

In the future, the ability to improve energy monitoring will require,

1. The availability of high resolution data.
2. Software that can analysis the data.
3. Sub-metering to isolate particulars zones in a building.

More generally, commissioning a building prior to occupation will need to make sure the data monitoring equipment is fully operational. This was not the case across phase one. Indeed because sub-metering (3) was not available, the researcher was unable to carry out a full energy audit which would isolate specific services (e.g. lighting etc) as well as zones in a building (A, B, C etc).

6.1.4 Commissioning - Anecdotal feedback

6.1.4.1 School C

Based on the year 1 energy data, School C had the lowest EPI score out of the phase one schools, although these figures did not take into account the associated emissions from the biomass system. At the time however, there were many concerns about the building's energy performance as the emails below help to confirm.

'*We went to school C last week and had a tour as part of the workshop we were running. I spoke with ... their business manager and he had some pretty significant news... they have just received an energy bill which is three times the amount they were paying in the old school!! They used to pay £6,000 a month and are now being charged £21,000!!!' Email, Primary Supervisor, 18th January, 2010.*

'*The Governors are concerned about the schools energy costs and the delay in getting energy related problems fixed... Governors are looking to you to provide them with evidence to "get things fixed quicker" and in to inform the next phases..." Email. Governor, 7th May, 2010.*

'*The Governors Finance Committee are concerned about the potential costs to the school of the PFI agreement. They are likely to have a separate meeting with the builder to address energy supply and the operation of the building is part of this*' *Email. Head Governor, 7th May, 2010.*

Under these difficult circumstances, and with no official or reliable data to rely upon, the researcher exercised his discretion to remain an impartial observer, documenting what was said during this challenging period. The evidence presented below is of an anecdotal nature and considers the different positions held by the various stakeholders including the business manager and various members of the FM team.

On the 22nd March 2010, the researcher visited the FM staff at School C. During this meeting a variety of issues were discussed. The researcher was looking to qualify the concerns outlined in first email above from his primary supervisor. Indeed, when the question of utility data was presented to the contracts manager, he explained how they were attempting to eliminate both hardware and software problems. For clarification, the researcher asked for more details about the problems they (the FM team) were encountering, noting down the following issues,

A = Education; B = Community; C = Environment; D = Technology; E = Economics

- *Incorrect wiring of local thermostats – they control another room's temperature!* ***[D]***
- *Equipment installed but either unplugged or not configured - therefore no data available.* ***[D]***
- *Software not working correctly – requires additional programming.* ***[D]***
- *Biomass boilers used in winter only.* ***[D]***
- *Residual ash from the biomass thrown away.* ***[C]***
- *Gas boilers work in summer and winter. Cheaper to use compared with Biomass.* ***[E]***

Source: Notes taken at school C during meeting with FM Team, 22nd March, 2010.

It was at this point in time when the researcher's primary focus shifted away from the specific issue of energy consumption to the less familiar activity of building commissioning. Indeed, when the conversation moved onto the issue of accountability, FM staff were quick to respond, explaining how in their opinion,

- *The builders lack skill/knowledge/expertise to deliver faultless buildings.* ***[D/A]***
- *Need for continuous commissioning.* ***[D]***
- *Occupancy deadline may be too close before systems can be correctly configured.*

Source: Notes taken at School C during meeting with FM Team, 22nd March, 2010.

Having established the main issues which FM staff were now attempting to resolve, the researcher was taken on a brief tour of the building. During this inspection aspects of the design were discussed including the minimal role the FM provider played throughout the design, construction and commissioning phases**.**

To the right, the picture shows extensive piping required to supply the gymnasium with heating and electricity. In the opinion of the Contracts Manager, the gymnasium at School C would have benefitted from a dedicated energy plant, similar to the one installed at School A in order to improve the building's overall efficiency.

Image 12. School C Pipe-work

Zonal controls also were not configured as part of the BMS system. This meant that the building's heating system could not accurately respond to specific needs. For example, the communal areas with large external windows that captured the views out onto the countrywide were often too hot due to excess solar radiation. At the same time, other areas of the building would remain cold.

Moreover, when the researcher was discussing the challenges of working in a school environment, the following comments were made by the FM staff,

- *The behaviour of building users needs to change – switch off lights etc.* ***[A/B]***
- *ICT and other appliances not set to auto-shut down mode.* ***[D]***
- *Requires staff and students to undergo basic training.* ***[A]***

Source: Notes taken at School C during meeting with FM Team, 22nd March, 2010.

Whilst each explanation was reasonable, at no point did they accept or concede that any of these issues were in part the FM team's responsibility. In this regard, the public-private-partnership was not fostering a culture of team work and cooperation **[B]**. Indeed, when finally the FM team were invited to comment about the likelihood of creating "low-carbon" schools in the second and third wave projects, a lack of money was cited as the major problem.

Some months later when the researcher visited the FM team for a second time, problems between the public and private sector partners had escalated to a level where they were no long willing to discuss in detail specific aspects of School C's operational performance. As a result, it was not possible to confirm whether the school's BREEAM rating had been downgraded from 'Excellent' to 'Very good'. Whilst frustrating for the researcher, the FM project manager, was happy to divulge information of a more general nature.

- *BeMS commissioning needs careful tweaking and should be done straight away.* ***[D]***
- *Under-floor heating response time too slow.* ***[D]***
- *Priority is size* ***[A]****, radiators reduce floor space.* ***[D]***
- *Air tightness improvements in our temperate and variable climate make under-floor heating not suitable or affordable.* ***[D/E]***

Source: Notes taken at School C during meeting with FM Team, 28th May, 2010.

At this juncture, it has been interesting to compare the position held by FM staff, with the views and opinions articulated the Business Manager at School C. It is also worth noting how the business manager was an active member of the school's BSF "project" team (in addition to the head and the deputy), acting as the school's technical representative, having previously worked as the principle caretaker in the old building.

The first thing to note was the health and safety issues concerning the biomass boiler which (incidentally) the FM provider had not mentioned. He explained how some of the teachers working in particular rooms were complaining about sore throats, ear aches and the smell of "burnt fish".

> "*I have asked them [FM staff] to get some data from the biomass fuel providers if there are any hazards... I have had no feedback... their answer is to turn off the biomass, so next year the problem will come back..." (School C, Business Manager, 25th May, 2010)*

During this visit the researcher was permitted to inspect the biomass system which was situated underground in the main plant room. In attendance was the researcher's second supervisor, Dr Neil Brown (NB), an engineer by training. Photographs were taken of the biomass boilers, identifying substantial deposits of ash which had collected on top of the apparatus. This, School C's business manager suggested, may have arisen due to inadequate commissioning, which by extension may explain the problems associated the unpleasant odours.

Image 14. School C Biomass 1 photo

Image 13. School C Biomass 2 photo

Escalating these concerns by reference to the FM contract, the business manager explains,

> "...*if come October next year we still have that same issue, the smell etc, I will go back to the date I raised the issue about the smell of burning fumes... and contractually we have the right to take money* ***[E]*** *back from the contractors"*

However, it was still not clear who was directly responsible for the performance of the biomass system. Moreover, it was now emerging how the decision to select biomass on the basis of cost **[E]** and environmental credentials **[C]** did not fully consider the practical reality of operating and maintaining this system **[D]**,

> "... *the biomass is like burning coal… and it continues many hours after its turned off… you cannot just stop it burning the wood …" (School C's Business Manager, 25th May, 2010)*

Moreover, with the FM provider confirming how a lack of "zone" controls **[D]** restricted their capacity to configure the heating system, the Business Manager independently comments,

> "*... I've been in here on Sundays when we've had nothing on in the main building... and it's 26 degrees and we think wait a minute … we've raised this with the FM provider, and it was only until last Thursday they turned the biomass boilers off" (School C, Business Manager, 25th May, 2010)*

From a purely logistical point of view, compared with the relative simplicity of gas, during winter 2010, weekly deliveries of biomass were struggling to keep up with demand **[D]**. Moreover, to compound these problems associated with the aforementioned issue about biomass woodchip burning for many hours beyond what is required, the response rate of the under-floor heating system **[D]** was also connected to the overheating problem.

> Business Manager: *... a radiator you can just turn off, in 5 minutes its cold, the heat in the slab takes more like 3 to 4 hours to cool down.*

> Engineer: *... under-floor heating is great in colder countries and in the depths of winter, but the weather is too variable in this country, and with the insistence of BREEAM for extra insulation, sometimes you just need to heat up the air.*

More generally, the failure to properly commission the services throughout the building, including the online database **[D]**, made the post-occupancy analysis more difficult. This was particularly troublesome for the PhD student who had assumed the online database would become the primary source of information that would shape his research.

Issues concerning the PIR automated lighting system **[D]** were also identified as a problem. Indeed, when the researcher visited School C on numerous occasions, he observed how lights were often on although there was sufficient daylight present.

> "*... the Building Management System (BMS) should have been commissioned prior to completion and there is always going to be a few tweaks along the way, and nobody knows whether the lights are going to stay on day to day, because the guys commissioning it will only have put it down to a device standard, so if it's a dull day it's not going to take into account if its bright etc." (School C, Business Manager, 25th May, 2010)*

What has emerged from these initial discussions demonstrates how inadequate commissioning can have negative implications in terms of the professional relationships which develop **[B]**, the efficiency of the building **[C]**, and most importantly, the comfort of the building in terms of supporting the teaching and learning activities **[A]**. One provisional conclusion that can therefore be drawn is the need to resource (time + money + expertise) the commissioning phase in relation to the complexity of the building. At School A, the building was smaller, more straightforward, and was ready to go at the point of occupation. At School C the qualitative evidence suggests this was not the case. To support this process, the Soft Landings Framework was a project management system that operates throughout the building process from design, construction through to site maintenance. Continual commissioning is another recommendation which may wish to involve not only the builders and the FM provider, but the actual component manufacturers, the engineers and finally the architects.

Moreover, when the official “walk-round” inspection was arranged on the 8th July, 2010, inconsistencies between the ‘as fitted’ drawings (final design) and the completed building were highlighted **[D]**. Historically (up until the 1980s), the ‘Clerk of Works’ would police quality control and conformity to the ‘as fitted’ drawings as the project progressed. Nowadays, with increasing numbers of sub-contractors working on a single project, systematic documentation may help prevent early mistakes going unnoticed (or being ignored) as well as leaving a paper trail so that future projects can understand why decisions were made and learn from past mistakes (hence the need for documenting feedback as exemplified by the Soft Landings Framework).

Furthermore, gathering feedback has not been a customary tradition of the construction industry. This will need to change if building design and post-occupancy operation is to improve and become more efficient. As an example, the business manager explains why in his view the music room has been seriously compromised,

> “*... the design phase was clearly defined,... the music room would be used for keyboards, ICT and would have 26 students and we spent 2 days to plan the layout and equipment, and there is no air conditioning **[D]** in there.... and the contractor did not take on board these clear instructions and now the music room is unusable **[A]** as the temperature can reach 30°C” (8th July, 2010)*

It was also evident by Business Manager’s comments that he felt constrained by the limitations of his new role (as business manager, formerly the caretaker),

> “*... the BMS is set to 21°C, but where we know it’s going to be very hot, we would ideally want to set the school to be 15°C or 16°C early in the morning so when the children arrive their additional contributions will not over shoot the 21°C. So it’s frustrating that we have no control.” (Business Manager, 8th July, 2010)*

In one particular room (Mathematics, H6), the business manager (BL) and the resident teacher (Mr.H) describe the problems facing the “modern” classroom.

> BL: *Typically the blinds are all shut because of the reflection of the sports hall (its white) and because the sun hits these rooms all day it gets unbearable and if you open the door*

*then it's noisy... The BMS should pick up the temperature in the classroom **[D2]** and the Trend machine should tell classroom H6 to switch on mechanical ventilation but there is no supply...*

Mr.H: *There is no air coming through the vents in my classroom, but in Katherine's classroom you can feel the air coming out... When we had a close humid day last week it was nasty. Open the windows and the blinds blow. The interactive white board requires the blinds to be shut and the projector is not as bright as it was when new.*

In summary, School C was a large building with a complex HVAC system. Evidently the "one-hit" commissioning was insufficient to prepare the building for occupation. Extending the business manager's responsibilities to include a more hands-on role (if he/she so wishes having previously been the caretaker) may also help to facilitate a closer relationship developing between the school and the newly appointed FM provider.

6.1.4.2 School B

The researcher visited School B on the 14th July 2010 to discuss the first year of operation with the business manager. Similar to School C, the main issues facing the school included ventilation and overheating problems **[D]**.

The first topic to be discussed was the heating system. In winter, one week after Christmas, the under-floor heating system failed. According to the business manager,

"*... they [the FM provider] had to flush out the under-floor heating. They did not know why or what caused it ... [and] with the school open they could only work on part of the problem outside of the school hours. It took two weeks to fix..."*

As a result, water, gas and electricity consumption **[C]** all increased during this period.

Overheating was linked to the ventilation system which had not been commissioned correctly. School B's business manager also explained how the original design was supposed to include external shading to protect the building from excess solar radiation.

> "*It's now summertime and ventilation is an issue. Air conditioning is in the ICT and the Head's office. The building does not seem to cool down in the evening. My office is 26°C in the morning and gradually increases throughout the day"*

Moreover, according a member of the council's BSF team,

> "*... the FM contractor has only just captured the temperature sensors data... they have not taken control of the CO_2 sensors. There needs to be night time ventilation **[D]**. We've struggled to get the FM company to be pro-active about it; contractually you have to be over 28°C for 120 hours. So the premises manager has been coming in early in the morning and opening all the windows but it takes 1h30... and obviously we cannot keep the windows open at night due to security issues."*

From an engineering perspective **[D]**, the HVAC system incorporated natural ventilation. However, there was no mechanical cooling built into the ventilation system. As a consequence, the business manager explains how it was difficult to detect whether the supply vents were in fact working properly as there was no cold air entering the classrooms. In addition, the commissioning of the ventilation fans, (according to the IESD Engineer) should include a "ramp function" where the air flow (ventilation) can be increased or decreased depending on the level of CO_2 or temperature.

In some cases, the HVAC system was simply not working at all. Indeed when questions were asked about the details of any "value-engineering" **[D]** decisions, the following points were raised,

> ***LCC:*** *Trend needs to come and do a full energy audit... this will look at the original spec, what was removed, what's currently here... and then they can evaluate whether the present strategy is inappropriate.*
> ***Engineer (IESD):*** *Was there a log kept of the changes?*

BM (School B): *Yes, a derogation log will show this which Sam can get. The cost savings* ***[E]****... the room data shows sheets no longer include air changes. Some had 60 a/c. You should be able to measure this from the AHUs. So the kitchen is 60 a/c. A typical classroom is 8 litres a second per person. The sheets have lots of incomplete fields relating to the designers not specifying physical properties of a room.*

In terms of the ventilation controls, the Business Manager explains how each classroom has a black button which the teacher can activate.

"*The cooling regime is to open the windows or they press the "black button" which is supposed to boost the mechanical ventilation, only they have not been wired up locally* ***[D]*** *and there are blocks of 4, 6 or 8 classrooms which are simultaneously affected by one teacher pressing the black button in their respective classroom. Therefore, more often than not, the affect is minimal* ***[D]*** *as the boost may have already been activated by another member of staff."*

Indeed, with some of these operational issues linked to the contractor not following the precise instructions of the 'as fitted' drawings, a lack of quality control in the construction phase has created problems which are more complicated to resolve. Moreover, it was then became the responsibility of the FM provider to address these flaws post-occupancy, although they were unfamiliar with the installed technologies.

School B-BM: *I think the problem is operation. So if we consider the various tiers. The FM team are in their 50s, and they simply cannot understand the complexity of the building. The FM provider simply has not trained them.*

Engineer (IESD): *This is common across the built environment. You need to be an engineer not a site manager.*

School B-BM: [Name] *is the roaming "engineer" who fixes the four BSF buildings.*

Moreover, the engineer from the IESD explained how the problems encountered at School B were symptomatic of a "one hit" commissioning process **[D]** that underestimates the time and resources required to fine tune a modern complex building like School B.

> "*... so seasonal commissioning is something – post-occupancy. But then you need to revisit where a winter is harsh or indeed a summer is hot. This is continuous." (Engineer)*

Furthermore, it would seem that both business managers at School C and B were equally frustrated by the limitations of their new position, prompting the following comment.

> "*The school needs an active role in controlling the environment" (School B, BM)*

In addition, further wiring problems associated with the HVAC system were also identified during the walk-through inspection. The kitchen's ventilation system for example was designed to operate at 200 litres per second but was not working **[D]**. As a result, the fire exit door was often left open, contravening food hygiene rules, in order to alleviate what the business manager described as "unbearable" humidity. In addition, the extract grills above the hobs in the Food Technology rooms were not working.

As a result, concerns were growing about the FM provider not fulfilling their contractual responsibilities. Indeed, as one governor at School C explained,

> *"... and every time they [FM provider] do something it is a cost to the school; the school's got to pay whereas in the past it would just be absorbed or someone would work an extra half hour without any questions but now it's all money money money. Anyone who asks for something to be done has got to go through someone else for it to be approved"*

In conclusion, the anecdotal evidence, combined with the observations made during the site inspection, confirm many of the same issues encountered at School C. In both schools, no zone controls were in place. This meant that whilst some parts of the building would overheat, others were too cold. More often than not, solar radiation penetrating the curtain walling was responsible for the overheating. A failure to commission and test the HVAC systems also led to air quality issues arising. In one instance, this included fumes from the biomass chimney finding their way into natural ventilation system. The under-floor heating system in combination with the biomass system was also too sluggish to respond to external temperature variations. Indeed, whilst the standard radiators installed at School A reduced the amount of usable space, any problems (as will be discussed in the next section) were quickly resolved. Simple solutions like this were not possible at School C and B. Indeed, it was the pressure to complete the schools on time, given, which inevitably limited the capacity to properly commissioning the building services. Furthermore, with the design team effectively removed from the commissioning process and with the FM provider not involved in the design process, it was left to a single “roaming engineer” to ensure acceptable standards of operation were maintained across all four schools throughout the first year operation.

6.1.4.3 School A

At School A, the formal walk-round inspection to include members of the IESD staff, the city council and the FM provider was scheduled to occur on Wednesday 14th July 2010. Unfortunately, for reasons unbeknown to the researcher this appointment was cancelled. However, the researcher did visit the building on a number of separate occasions where he had a very constructive discussion and tour of the site with the FM site manager.

With the design reflecting the limited budget which had been extended to allow a new build project to commence, School A’s new building was working surprisingly well from day one. It had been suggested the simple layout, conventional gas boiler and standard wall mounted radiators **[D]** allowed for a straightforward commissioning process. However, since there was no business manager in place at this time, it was not possible to corroborate this suggestion. As a result, feedback taken from the staff occupancy survey **[B]** has been called upon to validate this position.

When the researcher did visit the building, he made notes of any problems staff mentioned as he moved from room to room. In some cases staff complained about feeling too cold or too hot. As a result, FM staff checked, adjusted and/or replaced faulty radiator thermostats. The building’s temperature target was set at 21°C.

The major problem which numerous staff mentioned were the main entrance doors at reception **[D]**. Basically the glass hatch where guests sign in and make enquiries was located too close to the automatic doors. This meant the doors were frequently opening and closing when people were waiting to speak with the reception team. As a result the foyer/entrance area was mostly draughty and cold throughout colder months of the year. To remedy this situation, a small extension to the entrance door has been proposed **[D].**

As the building was providing a relatively stable and satisfactory environment for staff and students, it was interesting to consider how much energy the building was using. Interestingly, the internal lighting was identified as one aspect of the building which could be improved. The FM project manager estimated that 50% of the building's electricity demand was lighting. Whilst specific data due to issues with the BMS system could not corroborate this estimate, the researcher did identify a study by Pegg *et al.,* (2007) which breaks down the electricity demand of 5 Academy Schools. As figure 44 confirms, the yellow segments identify the lighting proportion of the electricity demand.

1. Server and specialist computing (black)
2. Catering (green)
3. Office equipment (blue)
4. Lighting (yellow)
5. Fans, pumps, controls (black)
6. Cooling (pink)

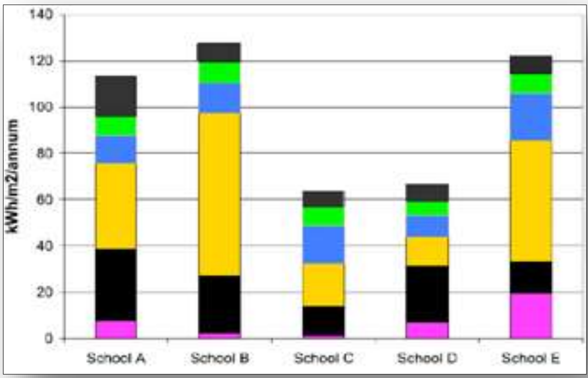

Figure 44. Academy Electricity (Pegg *et al.,* 2007)

To add some numbers to this 50% lighting assertion,

The building emits let's say, 500 tonnes of carbon per year with electricity contributing approximately 65% of these emissions (equivalent to around 330 tonnes). Now if lighting makes up about 50% of electricity consumption, that means lighting alone may emit around 150 tonnes of carbon per year.

With this in mind, the FM provider was clear about two things. They were not party to any design decisions about the specification of lighting equipment **[D]**. And secondly, they suggested the contractor operated on a "preferred" supplier basis. Moreover, with the FM provider now assuming the long term responsibility of the building's operational performance, the FM site manager was keen to instruct a specialist lighting company (Thorlux – see appendix) to carry out an independent audit. In a detailed report, their calculations indicate that a 50% saving could be possible if the existing system was upgraded. This equates to a maximum carbon saving of around 75 tonnes per year. Indeed, by applying a more conservative approach and halving this figure, emission savings from lighting alone may still amount to around 30 or 40 tonnes per year. With hindsight, if the contractor was contractually responsible for delivering an operational performance target for the first 3 years, then decisions relating to capital costs and profit margins also have to consider the operational long term aspects of energy efficiency.

To summarize, School A was a successful project which completed on time, on budget and satisfied the BREEAM design quality requirement. This allowed for a smooth transition as the staff and students moved into the new building. At this juncture, the qualitative evidence reported only minor issues relating to staff feeling cold. As a result, the FM provider was keen to investigate what energy efficiency improvements could be made. Upgrading the lighting system has therefore been identified. Future projects may wish to examine School A as an exemplar project making sure the decision makers, namely the contractor, have a vested commercial interest in terms of the long term operational efficiency of a building. To achieve this type of arrangement, new contracts and improved regulations will no doubt be required as previously discussed within the procurement chapter.

6.1.4.4 School D

On the 8th July, 2010, the researcher attending a walk-round inspection of the building accompanied by staff from the IESD and council members. Similar to School A. School B was without a Business Manager. As a result, a member of the FM team conducted the tour.

Image 15. School D, Library and Computer Room

The library and adjacent computer suite were the first areas to be inspected. As the picture to the right helps to illustrate, there were 24 Desktop PCs which remained on throughout the day **[D]**. To alleviate the effects of overheating, the automated windows which can be seen on this photo by their darker window frames, were programmed

to open and close automatically, allowing cool air from outside to enter the building.
To complement this strategy and encourage more air to be pulled in from the outside, warm air was extracted and channelled through the building into the central atrium. This type of natural ventilation strategy is called the “Stack Effect”. The rising hot air is then released through chimney vents in the roof **[D].**

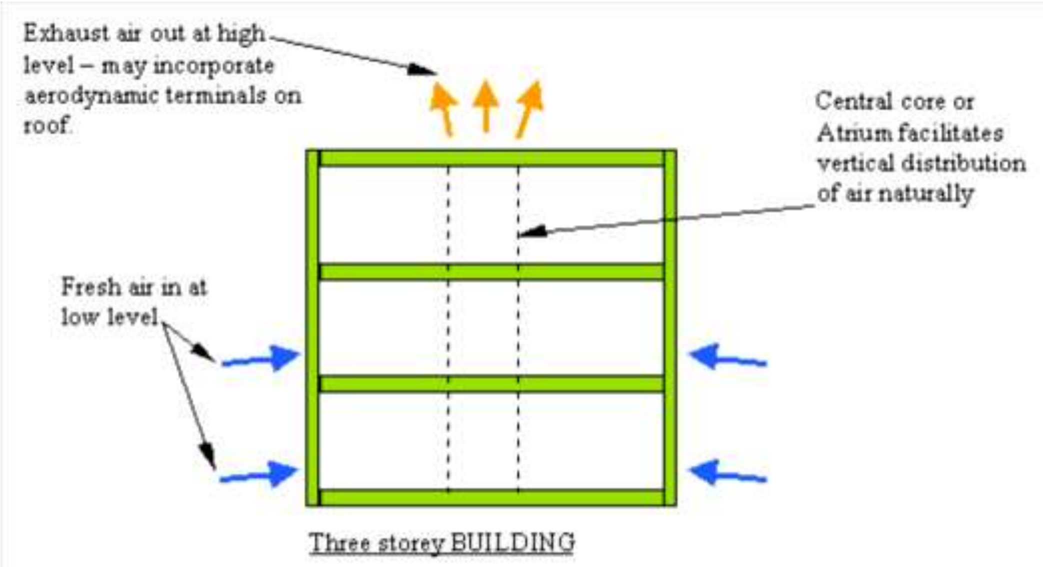

Figure 45. School D: Stack-effect (natural ventilation)

However, according to the FM team, the library only had a single extract vent. The lack of extraction resulted in the librarian keeping the door open to allow the hot air to escape into the atrium. Whilst this strategy appeared to be working, noise disturbances and interruptions made the library a less peaceful place to work **[A/B]**.

To complicate matters, there were two “supply” vents stationed in the library’s partitioned ceiling. Indeed, since the stack-effect is based on the one-way direction of air flow, these supply vents may have been inhibiting the natural ventilation strategy, possibly pushing air out of the windows rather than drawing (cooler) air in.

There was also uncertainty about whether the ventilation system was triggered by a build up of carbon dioxide or rising temperatures. In winter the automatic windows should remain closed. Supply of fresh air is therefore required. However, by reversing the fans so that a supply vent could also extract warm air would be one way to address the seasonal challenges presented by summer and winter conditions. As it was, the current arrange had inadequate extraction **[D2]**. It was also apparent how little the FM employee knew about the building’s HVAC system.

The inspection team then visited two science laboratories (see map on p.168 “labs”) which had no external windows. The researcher was told how BREEAM guidelines for “refurbishment” projects were more flexible, permitting windowless environments. Interestingly, the FM staff member was critical about the design and location of these science labs, explaining how,

> “... t*hey do not do proper bunsen burner experiments... virtual experiments instead... it’s all internal gains... you cannot feel any air movement... extract not great... an art room would be more appropriate” (FM Staff)*

The repartitioned office area in the refurbished section of the building was also a problem for the three administration staff who worked there full time. Indeed this claustrophobic environment, again with no external windows was described as a “nightmare” and more like a “cupboard” by the staff. Even the lights would occasionally switch off automatically as they were controlled by Passive Infra-Red (PIR) sensors as part of the BSF specifications. Evidently, this small room was not a suitable location to install a PIR activated lighting system **[D]**. The air quality was also described as “airless” and “stuffy” causing staff to become ill with colds and sinus problems. Again the supply and extract systems were not found to be working correctly. This meant that staff kept the door open to improve the air quality, but as already seen with the library, this invites noise disruptions when students are moving between classes and at break times. Evidently, this room was not suitable as a full time office space, although the regulations permitted its use **[D]**.

A number of technology workshops located in the refurbished section of the old building were also found to have various health and safety problems. Similar to the experiences identified by the administration staff, a technician from the technology department explained how the extract system was “woeful” **[D]**,

> “*We work here for many hours... No windows, no ventilation. We will have to stop working. Not just cutting but CAD work on the PC. Do your cutting Friday. Then work Monday Tuesday etc...”*

More alarmingly still, when the reprographics room was visited, the inspection team were told about how “Stephanie”, a full time administrator, had been suffering from chronic throat and cold problems **[C/B]**. Indeed with no regulatory requirement to monitor “humidity”, by working in close proximity to the photocopying machines, the dryness of the air was clearly a problem.

Furthermore, when the researcher was informed about the fact that another member of staff who had worked in this room had recently been diagnosed with “occupational asthma”, the inspection team were notably concerned about the health hazard this room posed **[C/B]**.

When finally the FM site manager completed his tour of the school, with numerous examples of inadequate extraction and ventilation identified, the “as fitted” drawings were inspected by the IESD staff in attendance. What they discovered were a range of inconsistencies between the architect’s drawings and the actual room fittings, prompting the following the comment,

> “*A vent grill should be in room G17 [the wood cutting room]... there is no air handling... no ventilation. It was previously a store room. Now its function has changed. Clearly the map does not reflect what is in the building. The Builder will be the first people to talk to... it’s not the FM provider’s problem, it’s the builder’s issue since the drawings are ‘as fitted’.” (FM staff)*

With hindsight, with this particular project overrunning by around 10 to 20 weeks, the “one-hit” commissioning was evidently not sufficient to ensure the building was ready for occupation. In the absence of a ‘clerk of works’, the commissioning procedures for future BSF projects need to be extended to include a more thorough and continual approach. Project complexity **[D]** also becomes a factor which needs to be considered in this regard. The bigger more complex projects evidently require more careful commissioning over an extended period. Ironically, the limitations placed on School A lead to a design that was quick to build and easy to commission.

Evidently, whilst conventional or standardised (modular) designs may not require the continual involvement of the design team, when projects such as School D become more complicated, the architects and engineers may be required on site to make adjustments. However, this is not common practice within “Design & Build” contracts.

Trust between practitioners therefore becomes more important. Developing long term commercial relationships also helps as does sharing responsibility above and beyond the contractual arrangements. However, the pressurised nature of procuring the first phase of BSF schools meant that time and budget limitations were also factors which undermined these social bonds establishing themselves **[B2].**

6.2 Re-commissioning - 2010 Energy Audit

This section briefly summarises the interventions carried out in the summer of 2010 when all four schools were re-commissioned by Trend, the BMS manufacturer. The two main problems under examination included, (i) energy efficiency ***[D/C]****, and (ii) environmental comfort* ***[A/B].***

Summarising the four audit reports, the information contained in the two tables below illustrate how the re-commissioning of the BMS system varied from one school to the next. The individual circumstances of each school may have also influenced the extent to which these savings were possible. School A for example had few complaints, allowing the engineer to focus exclusively on reducing energy consumption. By contrast, the other three schools were all experiencing a range of HVAC related problems, including overheating.

Table 20. Trend Re-commissioning – "Predicted" Savings (* Excludes Gymnasium)

	Energy Savings	CO_2 Savings	Total kWh	Cost Savings
School A	184,800 kWh (10%)	41 tonnes	1,836,759 kWh	£8,580
School B	179,350 kWh (7%)	48 tonnes	2,244,598 kWh	£7,320
School C	173,885 kWh (7%)	39 tonnes	2,407,060 kWh	£4,990
School D*	1,580 kWh (0%)	1 tonnes	1,793,295 kWh	£158

The second table then considers how upgrading the elements of the BMS system could help to further improve energy efficiency. As can be seen, it was School C that demonstrates the largest opportunity to reduce its carbon emissions, further evidence to suggest the building required more attention throughout the construction and commissioning phase **[D]**.

Table 21. Trend Re-commissioning – "Potential" Savings

	Energy Savings (£)	Energy Savings	CO_2 Savings
School A	£1,020	25,248 kWh	5 tonnes
School B	£2,420	24,330 kWh	13 tonnes
School C	£3,870	64,220 kWh	24 tonnes
School D	£2,190	54,190 kWh	10 tonnes

The next section looks in more detail at the changes made to each school **.**

6.2.1 School A

The re-commissioning of School A occurred on 5th October 2010. The report identified three key areas where the control settings needed to be modified.

(1) Central Heating Start-up Program

The heating for blocks A and B was originally programmed to operate for 45 hours a week, Monday to Friday. The engineer reduced this amount to 35 hours. In addition, the warm up time was previously set to 4 hours. Now the system was set to 2 hours using the “boost” mode facility that activates from 6.45am to 8.45am. These changes were predicted to save around 26 tonnes of CO_2 per year by reducing gas and electricity consumption

(2) The HVAC system

Fans which provide air heating can use considerable amounts of electricity. In accordance with the central heating changes, the air heating system was also adjusted to operate for 35 hours a week, saving a further 10 tonnes of CO_2 per year through electricity savings.

(3) The Sports Hall (Block C)

The sports hall’s heating settings were updated to operate for 35 hours a week. The quicker warm-up schedule also reduced the operation time by 2 hours which in total saved a further 5 tonnes of CO_2 per year through both gas and electricity savings.

The remainder of the report includes descriptions of modifications where savings could not be measured reliably. For example, the building’s low pressure hot water (LPHW) system was programmed to operate ‘on demand’ 24-7. This was adjusted so the system only operated around the 35 hour week to help extend the life of the components. In addition, the boiler thermostat was reduced from 90°C to 75°C.

Other non-quantifiable changes included updating the BMS software so that the three main gas boilers take it in turns to provide the primary heating in order to extend their operational life spans **[D]**.

Upgrading the controls so the school's heating system would also respond to outside temperature would help to improve the efficiency of the heating systems (degree-day analysis). Installing additional VAV boxes may also help to reduce the amount of electricity required to power the ventilation fans. At present, the ventilation is either on or off. VAV boxes can gradually respond to increasing levels of CO2 or rising temperatures to ensure conditions remain comfortable **[D].**

However, only 5 tonnes of "potential" CO_2 savings were identified, suggesting that School A was already operating close to its design limitations. School A also demonstrates how a project with a limited budget can help to focus the design process to create a simple and efficient solution. As stated already, future projects of a similar size and budget may wish to copy the basic design of School A, identify any opportunities to improve the "passive" specifications (i.e. thermal efficiency of materials), the "active" components (e.g. the heating system, lighting etc) or indeed the layout and construction (e.g. the entrance area). Any surplus money **[E]** can then be used to purchase bolt-on renewables **[D]** which may then help to engage students in the science of low-carbon technologies **[A]**.

6.2.2 School B

As the largest of the four schools with a floor space of 13,300m², in the first year of operation, based on the conversion figures published by the Carbon Trust* and DEFRA** (see table 23), School B produced 574 tonnes of CO_2 according to the official 2010 DEC figures (see appendix).

Table 22. School B Year 1 Official Energy Statistics

Data Source	Natural Gas (0.1836)*	Grid Electricity (0.5246)*	Biomass (0.015)**
kWh (2010)	1,462,897 (65%)	576,393 (25%)	205,308 (10%)
Tonnes of CO_2	269 t (47%)	302t (52%)	3t (1%)
Per m² (13,300m²)	20 Kg/m²/pa	23 Kg/m²/pa	0.2 Kg/m²/pa

Source: 2010 DEC Certificates (See Appendix B)

The anecdotal evidence collected thus far highlights poor ventilation as the main problem affecting the staff and students. Indeed, the business manager explained how the FM provider was now opening “smoke vents” in the classrooms to increase the air flow.

NB. *From a purely energy perspective, whilst the conversion factor of 0.5246 reflects the carbon efficiency of the grid to supply electricity, at present energy predictions of buildings do not properly account for the non-regulated use of “plug-in” appliances such as ICT. Reducing emissions in this regard will require both design teams and ICT provider (in particular) to integrate their products and services.*

6 categories (4 separate BMS updates, 2 proposed hardware upgrades) have been identified,

(1) The Heating System

School B used both under-floor heating and warm air to manage the internal temperature. Throughout the building the timer control settings were reduced from 45 to 40 hours per week, Monday to Friday. The warm-up time was also reduced from 4 hours to 2 hours using the boost mode. In addition, the gymnasium’s extract fans were originally programmed to operate for 87.5 hours a week. This was reduced to 67.5 hours. Collectively, these modifications resulted in a carbon saving of approximately 22 tonnes of CO_2 per year**.**

(2) External Lighting

Originally programmed to operate 24 hours a day, 7 days a week, the external lighting was modified to operate within fixed periods. With a “Power” rating of 12.2 kW, the report calculates an annual electricity saving equivalent to 10 tonnes of CO_2 per year**.**

(3) HVAC Controls (Cooling Strategy)

Timer settings for Air Handling Units (AHUs) were modified throughout the building to reduce electricity consumption. Ventilation for example would activate in the mornings for both the kitchen and dining hall. This was changed so the dining hall ventilation only came on during lunch time (from 12 noon to 2pm). Other modifications included reducing the VSD[20] fan speeds from 100% to 80%. The engineer also identified how the fan speeds would only operate at maximum capacity if the temperature dropped below -20°C or above +50°C. This possibly explains why the ventilation system was failing to provide a comfortable environment for staff and students**.**

At the same time, the engineer increased the internal CO_2 threshold from 1000ppm to 1300ppm to prevent the ventilation system switching on unnecessarily. This modification would also help to reduce electricity consumption in winter when there were fewer reports of discomfort.

The night time ventilation strategy, similar to School B was found to be ineffective. The original commissioning would only activate the night ventilation when every temperature sensor in the building was above a set threshold (23°C). The controls were thus modified to calculate average temperature throughout the building. If one of the sensors malfunctioned or fell below the lower set point of 16°C then the heating system would switch itself on. For a gas-powered system, intermittent use in response to external temperature fluctuations is not a problem. However, at School B, the biomass and underfloor heating system were designed to operate for extended periods in order to achieve maximum efficiency. As a result, the system was modified so only the gas boilers would activate if the building's “average” temperature fell below 16°C **[D]**. As a result, the report also estimates that demand for air conditioning may fall by 15% following this adjustments.

In total, a saving of 8 tonnes of CO_2 per year was predicted. More importantly however, this example highlights the importance of installing and configuring technology which is set-up for the local climate. In this respect, the under-floor heating system, together with the biomass boiler, do not appear to operate efficiently **[D]** in response to the moderate yet changeable weather conditions in Leicester, England.

[20] VSD, Variable Speed Drive

(4) Hot Water

The final energy saving intervention to be carried out involved reducing the hot water timer setting from 84 hours per week to 55. By significantly reducing the required gas consumption, they estimate a CO_2 saving of 8 tonnes per year**.**

(5) Air Conditioning - future upgrades

As previously stated, the HVAC systems for all four schools were not fitted with a cooling element. This meant that secondary air conditioning units were fitted in specific areas. At School B there were x21 3kW units installed throughout the building. The report describes how the,

> *" ... A/C units serving the classrooms, Dance Studio, and Fitness Suite are enabled by the Trend BeMS but not controlled. The space temperature for these units is set via the local controllers. It was noted that these A/C units run all day* ***[D]*** *irrespective of the occupancy. The usage of these areas was investigated and it was found that the areas are unoccupied between 30% and 50%* ***[A/B]*** *of the total time. It is recommended to install the PIR sensors in these areas so that the A/C units are automatically turned off when the areas are not occupied"*

The cost to purchase and install this additional hardware was calculated to be £2,074 **[E1]**. Annual electricity savings were estimated to be around £1,960, equivalent to 11 tonnes of CO_2.

(6) Biomass - future upgrades

The biomass system was central to phase 1's environmental strategy. However, the re-commissioning report identifies a number of problems which relate to both the appropriateness of the technology as well as the original commissioning. For example, the domestic hot water system was attempting to initiate the single 500kW biomass boiler intermittently. Only when there is a "continual" demand for heat should the biomass boiler be activated. The report also explains how at present, the hot water cycles through all three (gas and biomass) boilers loosing heat along the way. Isolating just one boiler by installing an “actuator” would resolve this problem. Furthermore, the report recommends fitting the Variable Speed Drive to the heating system to improve the control of heat throughout the building **[D]**.

The report finally explains that by upgrading the control panel (at a cost of £10,000), a further 13 tonnes of CO_2 could potentially be saved through optimising the delivery of services. Zonal controls would for example allow part of the building to be shut down outside of school hours, so that only areas in use are heated. More generally, the accumulation of evidence across all four schools tends to suggest operational optimisation becomes increasingly more challenging as the building becomes more sophisticated. Commissioning procedures which take account of this suggestion may require more time and/or more money to support more ambitious projects.

6.2.3 School C

With School C emitting 604 tonnes of CO_2 in the first year according to the official 2010 DEC figures (see appendix), the re-commissioning activities had to address both energy efficiency as well as the overheating problems.

Table 23. School C Year 1 Official Energy Statistics

Data Source	Natural Gas (0.1836)*	Grid Electricity (0.5246)*	Biomass (0.015)*
kWh (2010)	1,010,750 (42%)	786,087 (32%)	610,223 (26%)
Tonnes of CO_2	186t (31%)	412 t (68%)	6 t (1%)
Per m² (12,000m²)	15.5 Kg/m²/pa	34 Kg/m²/pa	0.5 Kg/m²/pa

Source: 2010 DEC Certificates (See Appendix B)

The audit report confirms how the biomass boiler was switched off due to “operational issues”. It was also noted how the heating system in summer had been switched off manually rather than using the BMS onsite 963 computer terminal **[D]**.

The VT (Variable Temperature) heat pumps and the under-floor heating system had also been “manually” (physically) disconnected by FM staff, instead of using the 963 software terminal **[D]**.

As a result, it was not possible for the hardware and software to communicate between one another as the BMS system requires. Understandably, the BMS engineer recommended all FM staff attend the 963 training course. Had the FM provider been appropriately trained prior to the occupation of the building then many of the problems could have been avoided, moreover, the FM staff could have also continued to fine-tuning the building post-occupancy as part of a much needed continual commissioning strategy.

Further investigations revealed how the air-conditioning units were often left on, even when rooms were unoccupied. PIR sensors have now been installed and the control panels password locked to prevent students tampering with the control settings. As a result of these modifications, the engineer calculates a total saving of approximately 39 tonnes of CO_2 should be realised over the course of a year. It has therefore been interesting to examine the utility data in order to determine whether these predictions have in fact been realised.

NB. The evolving (mixed-methods) methodology was often influenced by "developments" such as this which in turn lead to further questions being asked e.g. Have the "predicted" savings following the changes made to the BMS controls been achieved in practice?

Four modifications were made affecting the Heating System, air-conditioning, Hot Water and the ventilation system.

(1) Heating System

In the main building the heating system had its occupancy hours reduced from 50 hours per week to 42.5 hours. In addition, the building's internal temperature target was adjusted from 21°C to 19°C in an effort to alleviate the overheating problems. Furthermore, the early morning warm-up cycle was adjusted so the building took only 2 hours instead of 3 hours to warm up in the mornings. As a result of these changes, predicted savings amounted to 15 tonnes of CO_2 per year.

The gymnasium timer settings were also reduced from 45 hours per week to 31.5 hours, saving a further 10 tonnes of CO_2.

(2) Air-conditioning

The air-conditioning units in the dining area were originally programmed to work 45 hours per week. This was reduced to only 10 hours per week in an effort to stabilise the heat gain when the students were having their lunch (12 – 2pm). The timer settings for the air-conditioning units in the ICT rooms were also reduced from 45 hours per week to 31 hours. The combined effect of these modifications would save another 8 tonnes of CO_2 per year.

(3) Hot Water

The operation time for the domestic hot water system was marginally reduced from 73 hours per week to 61.5 hours, saving a further 2 tonnes of CO_2 per year.

(4) HVAC System

Similar to School B , the air quality carbon concentration threshold for CO_2 was actually increased from 800ppm to 1300ppm. In theory this alteration should lead to a reduction in winter electricity consumption as the ventilation fans should come on less often. At the same time, since the summer months were causing the greatest occupancy discomfort, lowering the temperature set point was expected to increase ventilation and improve comfort. As a result, more electricity in summer may be required to power the HVAC systems. In addition, the BMS system was modified to prevent the 'Optimised Start Signal' (OSS) routine switching on fans when the building was unoccupied. By updating these settings, an annual carbon saving of 4 tonnes was predicted.

It was also discovered how the temperature monitoring equipment was incorrect by almost 7°C. As a result, the BMS controls were automatically switching the heating systems on. Indeed, because the underfloor heating slabs took many hours to cool down, the problems associated with overheating were the result of poorly commissioned BMS controls.

Potential Savings

With 6 “zones” to the building (A, B, C, D, E, F) the BMS system was unable to switch off specific areas of the building when not in use. This made the school less efficient as heating was frequently left on unnecessarily. Furthermore, the biomass system was not particularly well suited to providing only partial or intermittent space heating as woodchip continues to give off heat many hours after the boiler switches off. Indeed, with the underfloor heat slabs taking a similar amount of time to cool down (~4 hours), the response time of the heating system became even longer at both School B and C. Now factor in the associated problems with solar gain, and the management of overheating could be linked directly to the design and technology **[D].**

The energy audit also advised that by upgrading the control systems, a further 24 tonnes of CO_2 could be saved. Precision over the timely use of energy has emerged as an equally important aspect of energy efficiency **[D]**.

6.2.4 School D

As a refurbishment project **[D]**, there was limited scope to improve energy efficiency at School D through modifying the BMS settings. As a result the re-commissioning activities focused on the internal environment. The visiting engineer explains the situation as follows,

> “*The building does suffer from high space temperatures during warm weather. During the Controls Energy Audit, with the outside temperature at 19°C, the classroom vents were supplying air at 24°C with the space temperature approaching 26°C in some classrooms. The school has an upper limit of 28°C which has been reached and exceeded when the outside air temperature is high.”*

To help alleviate the overheating problem, the engineer modified the night time ventilation to initiate at 21°C when previously it had been set to 23°C. This meant that vents would open over night to help reduce the building’s temperature by the morning during summer months. However, it was also necessary to lower the heating threshold temperature so the building’s gas boilers would not switch on if the internal temperature fell below 16°C. Furthermore, whilst this strategy was helpful, the engineer recognised the limitations of this approach, noting, this *"will make little difference as the day progresses."* **[D]**

The only other modification of note was the adjustment to the timer settings. The original commissioning had programmed the ventilation system to switch on during weekdays from 7am to 5pm in the Drama room, Dance Studio and Music Room. Changing these times to 8am and 3.30pm was predicted to save a further 1 tonne of CO_2 per year.

Finally, by upgrading the controls so that the hot water system could operate on a 'demand only' basis (more like a domestic combi-boiler), a further 10 tonnes of CO_2 could be saved per year. This upgrade has now been implemented.

In conclusion, the opportunities to reduce energy at School D were very limited. In fact, given the problems with internal heat gains from ICT equipment, solar radiation, and a poorly commissioned HVAC system, energy 'may' have to increase in the future, especially during hot summers, if supplementary air-conditioning units are required to maintain comfortable internal temperatures.

More generally, the re-commissioning reports identify savings across all four schools simply by optimising the control settings. Furthermore, by upgrading the control systems, more opportunities were identified to improve the overall efficiency of the buildings.

Indeed, both the quantitative and qualitative evidence tends to support the view that buildings such as School A cost less to build, operate more comfortably, and consume energy in a stable and predictable fashion. By contrast, it may be harder for designers to understand why a complex building fails to deliver the predicted efficiency savings.

Evidently the economic benefits which accompany a standardized design approach may also encourage POE as design teams may find it easier to improve their products. At the same time, a sustainable school will also be shaped by the individual circumstances of a community (the "inputs"). In this regard, the "processes" which deliver a sustainable "outcome" must be acknowledged - repeat what works, avoid what fails, and endeavour to negotiate a solution which responds to the "needs" of the user. On this final point, design teams should be encouraged to work more closely with schools throughout the entirety of the project in the researcher's opinion.

6.3 The Biomass Strategy

From strictly a technology **[D]** perspective the first phase of the BSF programme adopted a "portfolio" biomass strategy in an effort to reduce carbon emissions across the 4 schools.

Originally, the Local Authority proposed that each school should produce at least 11% of their energy demands using onsite renewables. However when cost-benefit-feasibility analysis identified the various options such as CHP, solar PV, wind turbine, ground source heat pumps etc, they were all rejected on the basis of cost **[E]** and/or planning permission.

Under the circumstances, a conservative approach to the energy strategy was adopted, whereby two out of the four schools would have their gas boilers replaced with biomass equivalents. Indeed, by applying the economies of scale logic, the larger PFI schools were seen to offer greater efficiency savings. As a result, School B and C were fitted with two 500kW biomass installations.

This solution was also expected to satisfy the council's more general 11% renewables policy. However it was not clear on what basis the biomass system would be judged post-occupancy. Indeed, given that total energy was calculated to be 7,640,471 kWh for year 1, 11% of this amoutn equates to approximately, 850,000kWh (a target worth noting).

To help clarify this position with regards to energy and emissions, it was important that the online energy management system was properly commissioned and working. Unfortunately, the online system which Trend, the BMS manufacturer was supposed to maintain, was not working properly due to the commissioning issues previously discussed.

Image 16. iMat-2 Trend Online Database

Throughout the three years the researcher would regularly check the online system and compare this data with the manual meter readings written down by FM staff and the data which E-on provided. It was often quite obvious from visual graphics that the online system was unreliable. As a result, this jeopardised the capacity to carry out a forensic analysis of energy consumption, forcing the research to adapt to the data that was available.

Looking at sub-meter utility data would for example allow particular sections of the building to be isolated. In addition, a full break down of energy services, including lighting (previously estimated to be around 50% of electricity demand) could also be inspected, helping to identify opportunities to improve efficiency. However, without installing specialised equipment throughout the building himself, it was not realistic for the researcher to embark on a technically focused PhD project of this kind.

Figure 46. School B: Biomass Online

Moreover, when the researcher attempted to investigate the performance of the biomass boilers, only School B had a visible sub-heading titled ‘Biomass Heat Hourly’ (figure 46). Furthermore, when this data was converted into kilowatt hours and Carbon Dioxide equivalent, the results were not consistent with the megawatt hours (MWh) data which the FM provider recorded on spreadsheets (see appendix).

With uncertainty about the reliability of both sources of data, the researcher decided to contact the woodchip suppliers, English Wood Fuels. When finally the General Manager, responded to the researcher's enquiries, he confirmed that the woodchip storage capacities at School C and B were 20 and 10 tonnes respectively. He also kindly provided details about the woodchip deliveries which he confirmed were correct. As a result, the delivery data which the FM provider provided could be immediately discounted as the figures contained on the spreadsheet (see Appendix B p.361-362) were far in excess of the schools' woodchip storage capacities.

It is also interesting to note how the business manager at School C explained that biomass deliveries were required twice a week during the winter of 2009-2010, further evidence to suggest the biomass installation was flawed.

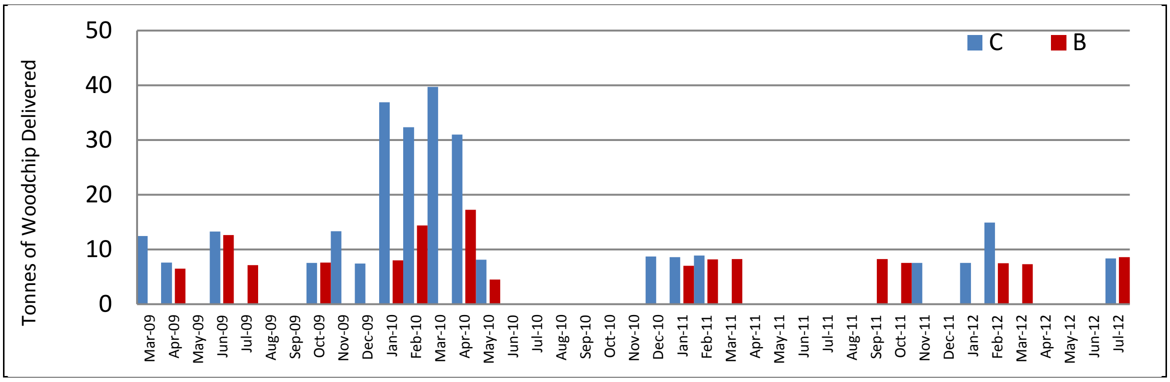

Figure 47. Monthly Woodchip Deliveries (2009 – 2012) Source: English Wood Fuels

In total, School B and C received 140 and 274 tonnes of Biomass Wood Chip from March 2009 to July 2012 during the first 3 years of operation. Using the fuel specification data which the General Manager at English Wood Fuels kindly provided, the woodchip had a 30% moisture content, equivalent to a "net" calorific value of 3,500 kWh per tonne. Using this figure it was now possible to estimate how many kilowatt hours the biomass system had generated. Table 25, compares the official DEC figures with the converted (tonnes into kWh) delivery data.

Table 24. Biomass Comparison Data

Source	School B	School C
Delivery Data (06/2009-06/2010)	272,580 kWh	733,320 kWh
Official DEC Data (2009-2010)	205,308 kWh	610, 223 kWh
Delivery Data (2009-2012)	490,000 kWh	959,000 kWh

Interestingly, the official figures published in the DEC advisory report (see appendix) add up to 815,531 kWh which when added to the gas and electricity consumption across phase one (7,640,471) produces a combined kilowatt hour figure of 8,456,002.

11% of this total then equates to a 930,160 kWh. Based on these calculations, year one biomass consumption achieves 87.6% (815531/930160) of the 11% biomass target. However, as figure 45 illustrates, woodchip deliveries effectively stopped during 2011 and 2012, due to the issues identified in the previous commissioning section.

Using the DEFRA carbon conversion figure of 0.0158, the woodchip delivery data (2009-2012) can also be converted from kilowatt hours (kWh) to its carbon equivalent (Kg or Tonnes of CO_2e).

- School B Biomass Carbon Emissions: 7742 Kg CO_2 => 7.7 t CO_2e
- School C Biomass Carbon Emissions: 15,152 Kg CO_2 = > 15t CO_2e

When staff complained about sore throats and headaches at School C the biomass boilers were switched off which explains why the deliveries stopped at this school. At School B, although no obvious health hazards were in evidence, the under-floor heating system had to be drained and re-commissioned and the HVAC system more generally was causing problems. Based on these technical issues the biomass was suspended throughout 2011 at both schools. As mentioned previously, concerns were now emerging about the practicality of running the biomass boilers **[D]** in addition to the associated costs with purchasing the wood chip fuel **[E].**

> *"... the biomass is like coal burning … and it continues many hours after its turned off… you cannot just stop it burning the wood… and I don't think it's as efficient **[D]**…. And it would be nice to see from the data… it would be nice to see the amount of money **[E]** that is being spent on wood chip and compare this with gas… and how much... " (School C, business Manager, 25th May 2010)*

The lack of data, especially in relation to the cost of buying the wood chip was a concern which needed clarification. Moreover, as it was not possible to extract reliable data from the online database, the business managers were powerless to investigate the situation. In essence, the two PFI schools running the biomass systems were unclear about the best way to proceed.

Looking at the price of woodchip using the data contained on the English Wood Fuels website[21] shows that 1 kWh of biomass heat energy costs approximately £0.314. Interestingly, when the General Manager at English Wood Fuels was asked about the limited use of biomass, he suggests,

> "*... the low use is partly explained by the comparative gas **[E]** price but the Facilities Management is also a major factor..." (E-mail, 9th October 2012)*

In a similar vein, the Business Manager at School C explains how,

> *"... the FM provider took a long time to understand how the contract works, inexperience... even now they are probably not fulfilling the full contract and it's something we are looking into, as we go through each service performance to see what all four schools get from the contract and if there are elements there which are missing which they should be doing..." (School C, Business Manager, 25th May 2010)*

It was also suggested how BREEAM "design" compliance was a factor in the decision making process which may have neglected to consider the "operational" challenges which the biomass solution would likely encounter post-occupancy.

> *"I would like to have had more time to understand all the energy saving elements... they [the Builder] had to get so many points and Biomass does create lots of points for BREEAM... we have ended up with a bit of a red herring… in that I don't believe it's what a lot of people believed it would do… the city council, the FM provider, the builders... don't believe the biomass system is working as we first intended to, the gas supplements it a lot more than it should do." (School C, Business Manager, 25th May 2010)*

Based on the weight of both utility data and anecdotal evidence, the biomass strategy has yet to deliver in terms of the expected carbon or cost savings. Furthermore, commissioning, maintenance, delivery and storage problems were also undermining the effectiveness of the biomass strategy. To compound these problems, health and safety concerns at School C meant that the biomass system was suspended midway through 2010 for at least one year.

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[21] http://www.forestfuels.co.uk/about-wood-fuel/fuel-price-comparisons

6.4 Full Energy Analysis (2009 – 2012)

This section compares the monthly metered utility data collected manually by FM staff with the half hourly electricity data from 2009 to 2012 for all four schools which Eon eventually provided. Helping to direct the analysis, three questions have been identified (i, ii, iii) **[D]**.

(i) To what extent does the "manual" and "half hourly" data vary (and why)?
(ii) Have the "predicted" savings following the re-commissioning been achieved?
(iii) What can the daily electricity profiles tell us about the operation of the buildings?

Interestingly, the BMS re-commissioning audit in autumn 2010 provides a key reference point to help examine the data and address questions (ii) and (iii). Question (i) is designed to investigate the logistical challenges of measuring consumption manually by taking down meter readings as well as relying on the energy provider. Moreover, with the BMS online database not working properly, detailed analysis using sub-metering could not be carried out **[D]**.

6.4.1 School A

School A has emerged as the benchmark building due to its simple design, limited budget and effective operation. Precisely how well it performs in terms of utility (gas water electricity) consumption provides a more quantitative measure of the building's "environmental" performance. Looking first at water consumption across the three years, the Carbon Trust (2005) benchmark figures[22] provide a quick indication of target water consumption figures.

6.4.1.1 Monthly Data

Using the monthly meter readings in cubic metres (m^3), a number of observations can be drawn from the bar chart on the following page. To start with, consumption dramatically drops in August 2009, 2010 and 2011 when the schools break for summer holidays. The second observation is that the trend line for water consumption shows a gradual rise across the 3 years. As water

[22] Good Practice = 2.7 m^3, Typical = 3.0 m^3, Poor Practice = 5.8 m^3 (per pupil per year).

consumption is generally seen to reflect the occupancy density or intensity of building usage (a proxy indicator), one simple explanation would be to suggest more extra-curricular **[A]** or community activities[23] **[B]** are now taking place in the building. To support this assumption, average monthly water consumption was highest (34%) in September, October and November during which time the school only has a single weeks holiday (Autumn half term).

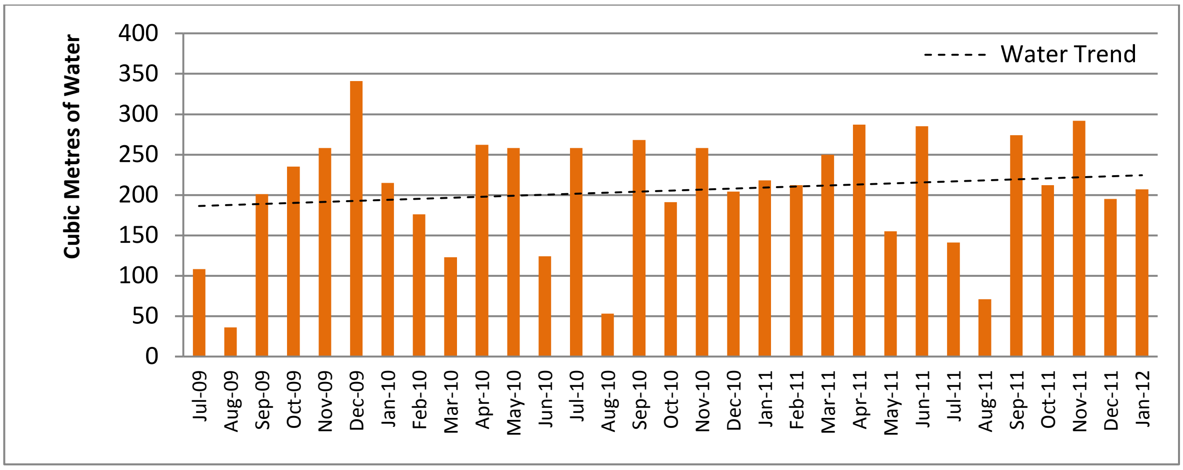


Figure 48. School A: Monthly Metered Water Consumption (2009-2010)

Table 25. Metered Water Consumption (2009 – 2012) (Source: FM data)

	Summer	Autumn	Winter	Spring	Total
Total (m³)	1076	2189	1768	1335	6368
Months recorded	8	9	8	6	31
Average (m³)	134.5	243.22	221	222.5	205.42
Percentage (%)	17%	34%	28%	21%	100%
Months	Jun, July, Aug	Sept, Oct, Nov	Dec, Jan, Feb	Mar, Apr, May	All

Given that School A accommodated 1,040 pupils, the three year average monthly water consumption of 205m³ equates to a benchmark score of 2.37m³ per pupil, far better than the carbon trust benchmark figure of ~4.7m³ for secondary schools. During this period, the price for a single cubic metre of water rose from £1.30 to £1.46 which equates to an annual bill of between £5000 and £6000 **[E]**.

[23] Kajima is an organization which manages and promotes the new facilities to the general public.

Looking next at Electricity and Gas consumption (figure 49) it is evident from the trend lines that gas demand reduces over the three years whilst electricity demand remains the same. Seasonal variation and holiday periods can also be detected using these basic monthly readings. High gas consumption in winter is particularly apparent by the rise and fall of the blue bars.

It is also easy to detect a marginal rise in electricity consumption in winter in order to provide extra energy for lighting and various other utilities including the pumps and fans that deliver the heating. Based on this evidence, the winter months unsurprisingly consume the most amount of energy.

It was also apparent how electricity consumption remained constant even after the modifications were made following the re-commissioning. This suggests, whilst the building may in fact be in use more regularly by the local community the energy efficiency may have improved following the autumn 2010 energy audit **[D/C]**.

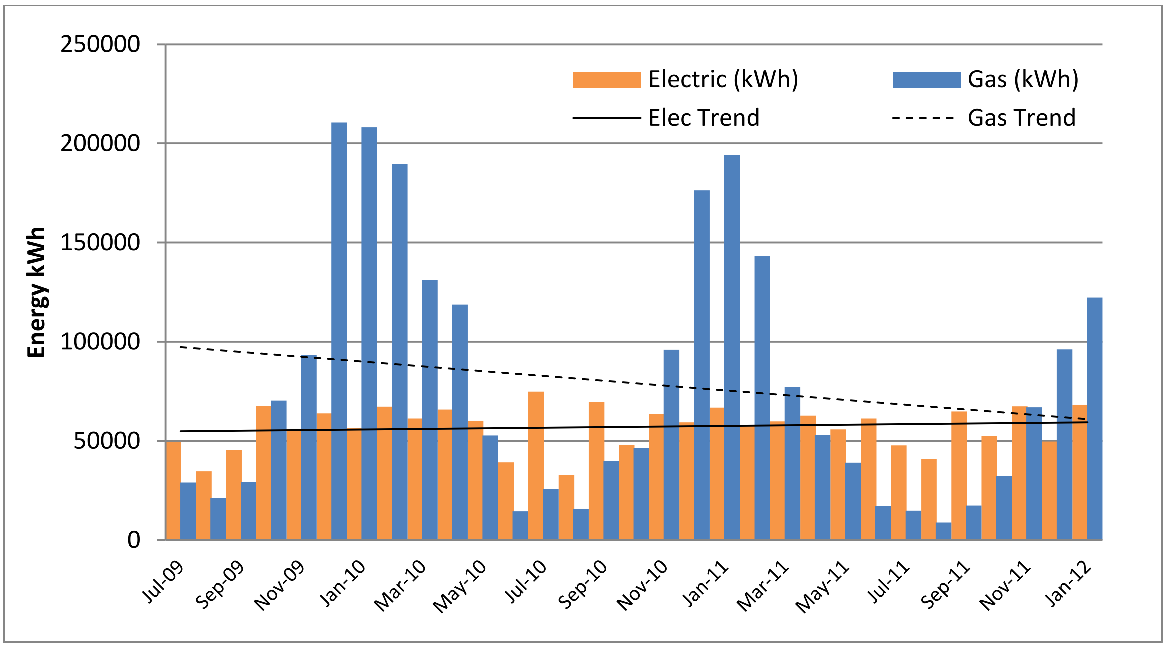


Figure 49. School A: Gas and Electricity (2009 – 2012)

Table 26. School A Electricity Consumption (2009 – 2012) (Source: FM data)

	Summer	Autumn	Winter	Spring	Total
Total (kWh)	381026	535067	489641	365623	1771357
Months recorded	8	9	8	6	31
Average (kWh)	47628.25	59451.89	61205.125	60937.17	57140.55
Percentage (%)	21%	30%	28%	21%	100%
Months	Jun, July, Aug	Sept, Oct, Nov	Dec, Jan, Feb	Mar, Apr, May	All

By referring to p.54, the literature review highlights a number of established benchmarks for schools based on existing electricity and gas consumption figures. For the current crop of BSF schools, CIBSE specifies a (normalised) target of 40 kWh/m²/per year for electricity efficiency. Using metered data collected by FM staff, electricity consumption from 2009 to 2012 averaged 64 kWh/m²/per year.

Looking now at the monthly recorded figures for gas, the original meter readings have been converted from cubic metres (m³) into kilowatt hours (kWh).

Table 27. School A Gas Consumption (2009 – 2012) (Source: FM data)

	Summer	Autumn	Winter	Spring	Total
Total (kWh)	147397	492390	1340522	472104	2452417
Months recorded	8	9	8	6	31
Monthly Average	18425	54710	167565	78685	319385
Average (%)	5%	17%	52%	26%	
Months	Jun, July, Aug	Sept, Oct, Nov	Dec, Jan, Feb	Mar, Apr, May	All

By referring to p.54 (again) it is now possible to calculate and compare how the normalised gas efficiency score of 89 kWh/m²/per year compares. Indeed, with CIBSE setting a target of 150 kWh/m²/per year for existing schools, it is likely that the benchmark target for new schools may need to be revised. This result also demonstrates why the regulations which determine the minimum thermal performance of a building are so important to reducing energy consumption.

In addition, the DEC system upgraded the status of School A from a D (yellow) to a C (green) rated building as a result of the year on year efficiency savings from 2009 to 2012.

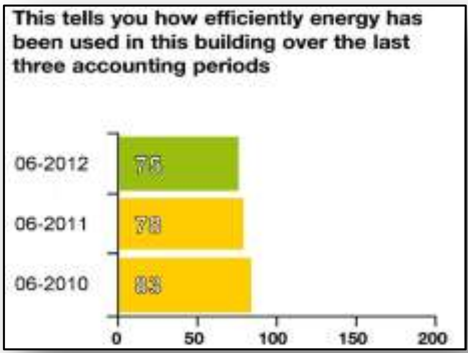


Figure 50. A: 2012 DEC Extract

The EPI (Environmental Performance Index) score was therefore calculated as 548 tonnes of CO_2 per year, which equates to 51 Kg/CO_2/m², with gas contributing 32% (174 tonnes) and electricity 68% (374) tonnes on average. Finally, CIBSE have published the follow benchmark figures:

"Good Practice":= 35 Kg/CO_2/m² and "Typical" = 46 Kg/CO_2/m².

6.4.1.2 Half hourly data (question iii.)

Looking next at the half hourly data which Eon provided, it has been possible to examine the daily profile of electricity usage and consider how the re-commissioning audit on the 5th October 2010 **[D]** may have changed the demand profile. Indeed, as the EPI score demonstrates, electricity consumption contributes almost 70% to the carbon footprint of the building.

For the purpose of clarification the terms “power” and “energy” have been explained below.

A kilowatt (kW) is a little bit like the speed someone travels in a car, for example 30mph.

A kilowatt (kW) is a unit of Power: E.g. Power is the rate at which energy is generated or used.

A Kilowatt hour (kWh) is more like the distance travelled in one hour.

A Kilowatt hour (kWh) is a unit of Energy: E.g. Energy is a measure of how much fuel is used over time.

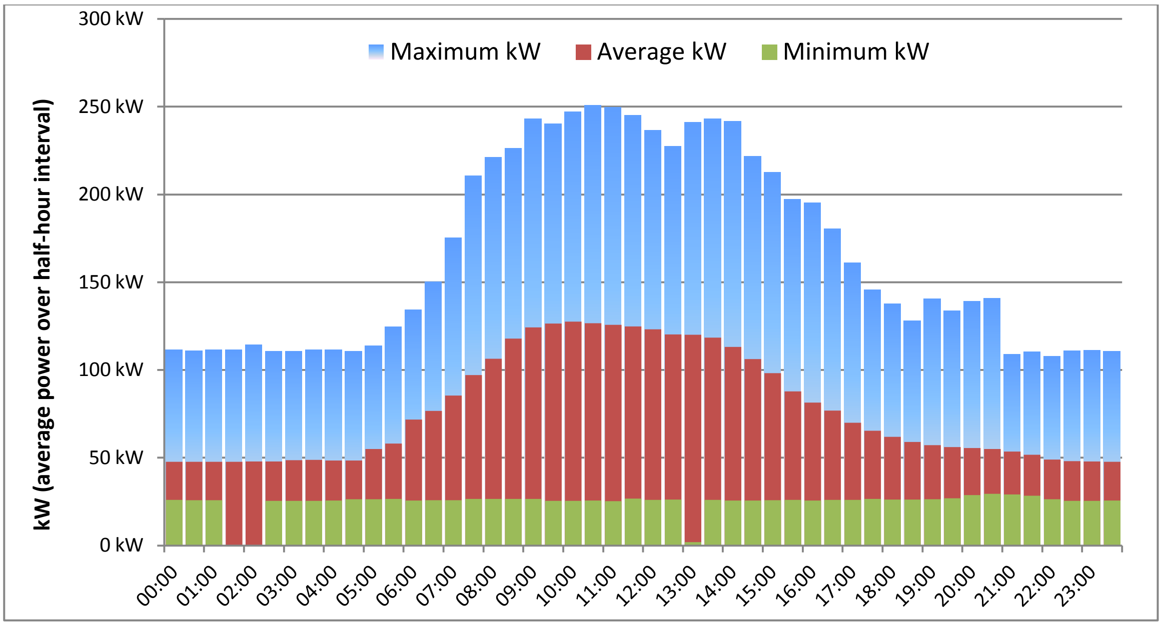


Figure 51. School A: Power Profile (2009-2012) (Mon-Fri)

Using Energy Lens which deals specifically with half-hourly data in excel, the red power profile represents the average consumption over the three years. The blue profile represents the maximum value at each half hourly time slot during this 3 year period and the green profile illustrates the lowest recorded energy consumption (holidays, weekends etc). A large gap between these 3 colour profiles may suggest the building is used both lightly and intensely. Alternatively it may indicate the building controls are not working properly resulting in unstable and excessive energy consumption. Likewise, a building that has a maximum curve close to the average curve may indicate the building uses energy in a stable and consistent manner. An office for example may have a predictable and steady demand profile Monday to Friday throughout the year (barring Christmas and Bank Holidays). It is therefore important to understand the “type” of building when analysing utility data in order to make judgements about the best way to improve performance.

It has also been possible to look at specific periods within the data. To start with, the data was normalised according to the schools’ total floor areas (W/m²). It was then possible to separate the data into weekdays and weekends. Most importantly however, and to address questions (ii) and (iii), the electricity data was divided into two sections – consumption before the re-commissioning (up to the 5th October 2010), and consumption after the re-commissioning (up to January 2012).

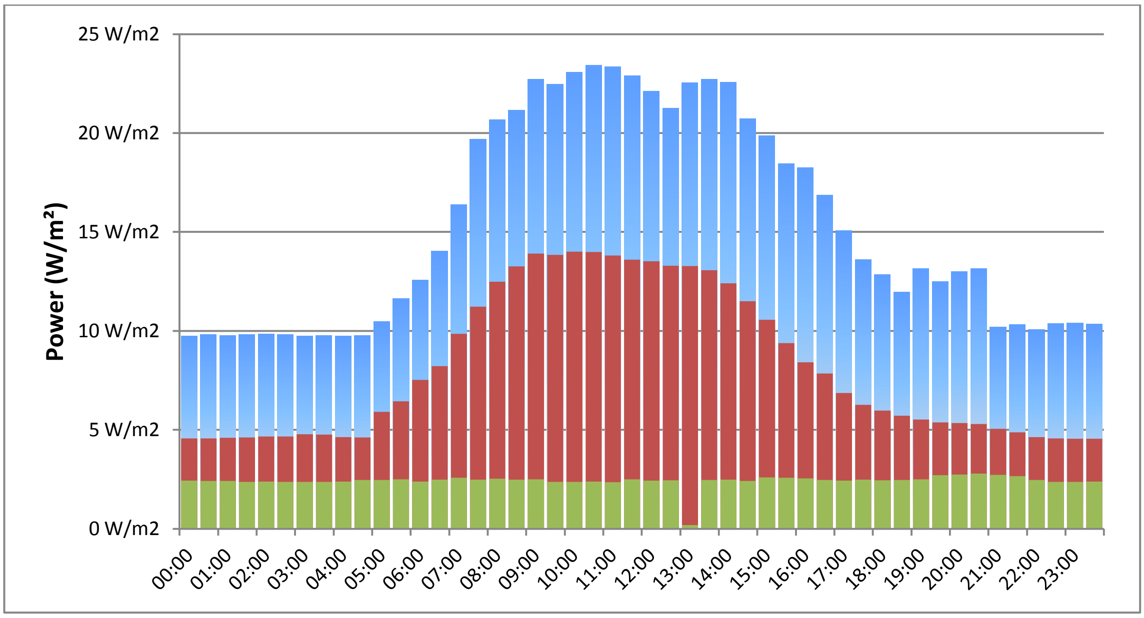


Figure 52. School A Normalised: Mon-Fri BEFORE Re-commissioning

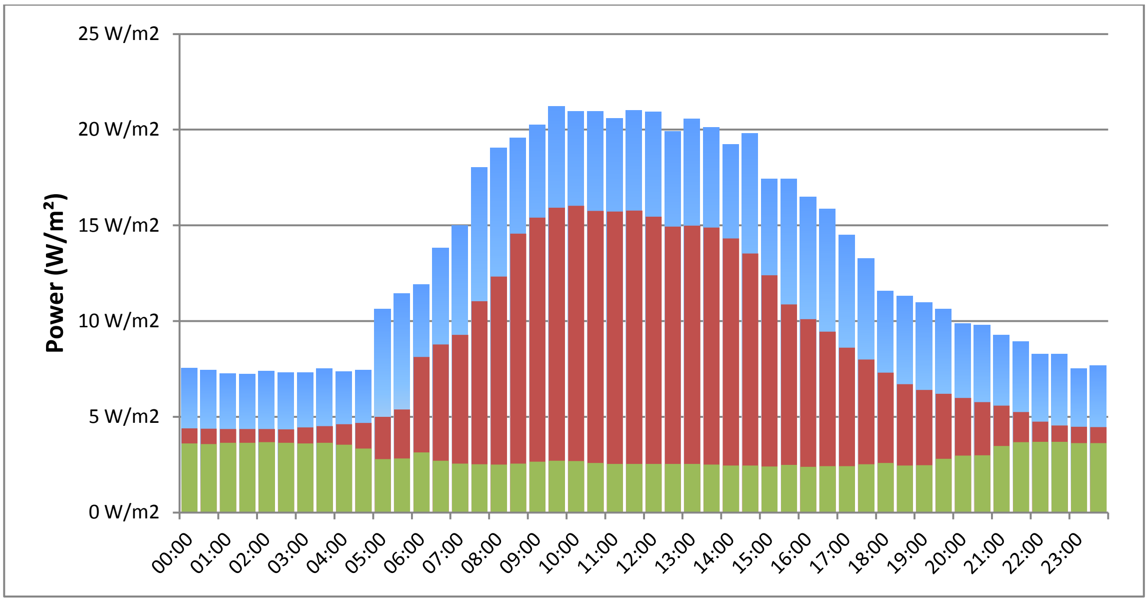


Figure 53. School A Normalised: Mon-Fri AFTER Re-commissioning

Most notable is the reduced gap between the maximum (blue) profile and the average (red) profile in figure 53, after the re-commissioning. In addition, as the monthly data has already confirmed, electricity consumption steadily increased. It was therefore interesting to discover how “average” peak load from 9am to 1pm had increased beyond 15 W/m² following the re-commissioning.

The ‘before’ and ‘after’ weekend profiles also illustrate how the maximum profile has reduced dramatically following the re-commissioning audit. It was also interesting to note how the shape of the average and maximum profiles may suggest the building was in use to a small extent. Future researcher may choose to examine Saturdays and Sundays separately.

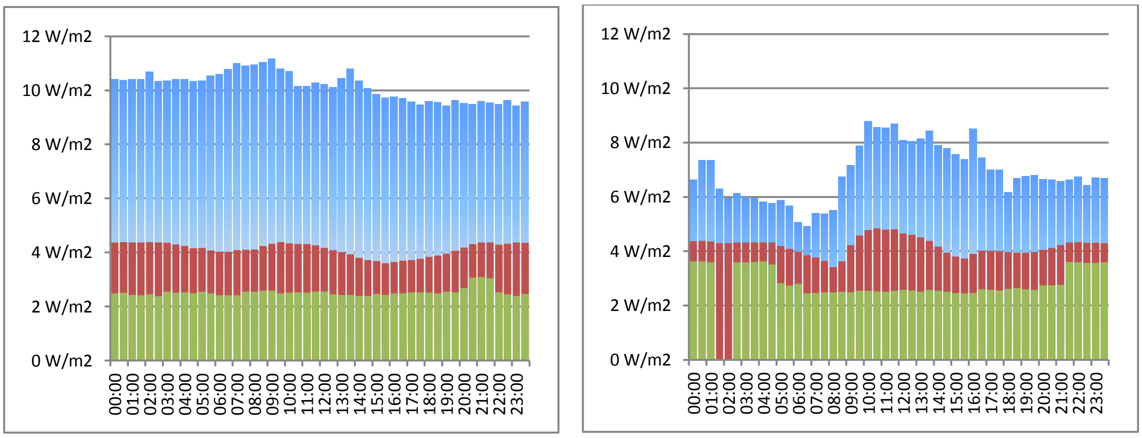


Figure 54. School A: Weekends: Before/After Re-commissioning

To address question (i) and to validate the metered data which the FM provider manually recorded with the half-hourly data provided by Eon, the bar-chart below illustrates the marginal variation between the two data sets. Indeed, by comparing the total consumption figures; (1,771,357 kWh FM provider data Vs 1,791,058.2 kWh Eon, half-hourly data) only a 1% difference could be detected.

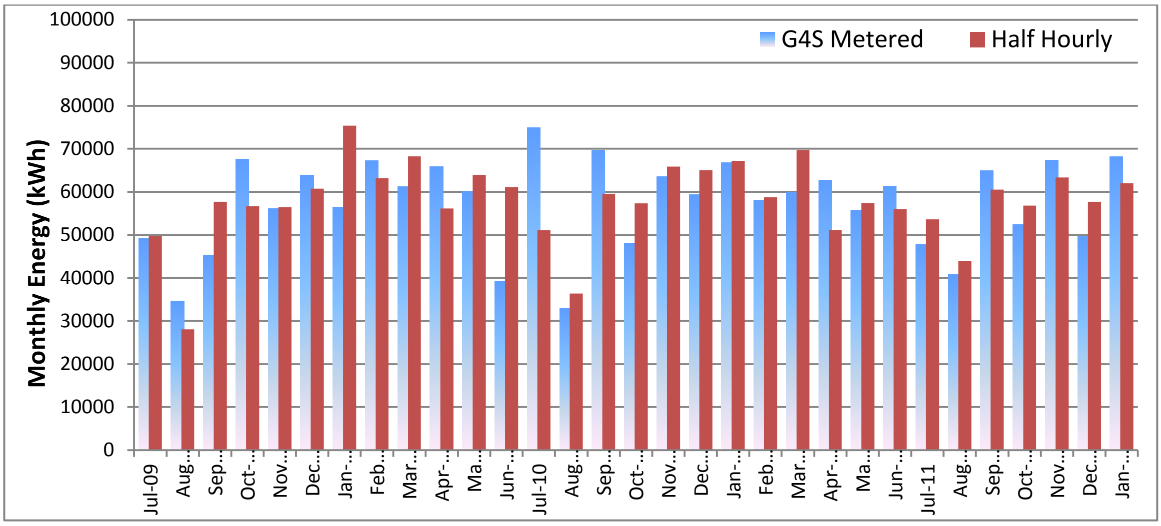


Figure 55. School A: Metered v ½ hourly Electricity data (2009-2012) (<1%diff)

To address question (ii), the re-commissioning report identified "predicted" savings of 41 tonnes of carbon. Prior to the energy audit, the first 12 months, from September 2009 to September 2010 emitted approximately 609 tonnes of carbon.

Looking now at the data from October 2010 to 2011 this figure had fallen to 557 tonnes, a saving of 52 tonnes. In both calculations, FM data was used.

Evidently, as the building's original commissioning was successful in terms of providing a comfortable environment **[C]**, this follow-up audit was able to focus mostly on energy efficiency improvements **[D]**. However, this example still highlights why continual commissioning delivered by site maintenance teams is central to achieving an efficiently managed building. In this regard, the audit report was right to recommend the FM staff attend the 963 BMS training course.

In future, Facilities Management personnel should ideally play an active role in the pre-occupancy commissioning of a building.

6.4.2 School B

Looking at the 2012 DEC, School B's official performance can be seen to fluctuate over the first 3 years. The second year "bar" indicates how 660 tonnes of CO_2 was emitted which in turn resulted in the building being downgraded from a C to a D rating (green to yellow) **[D]**.

NB. In the third year, the contribution from renewable energy has been included on the certificate.

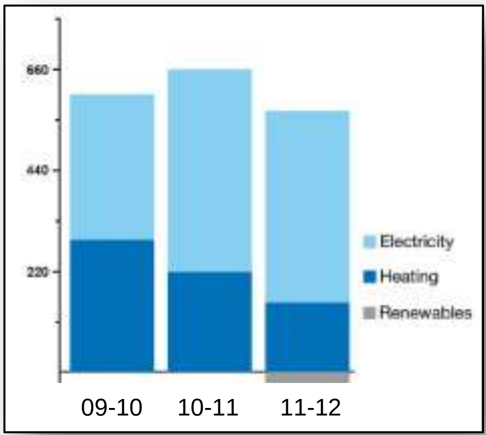


Figure 56. School B 2012 DEC CO_2 Comparison

It does appear however that gas consumption steadily fell year on year following the modifications made during the re-commissioning audit in Autumn 2010.

Looking next at the metered FM data validates this steady decline as figure 64 illustrates. Electricity also marginally fell slightly during this same period based on the same monthly metered data which the FM staff collected.

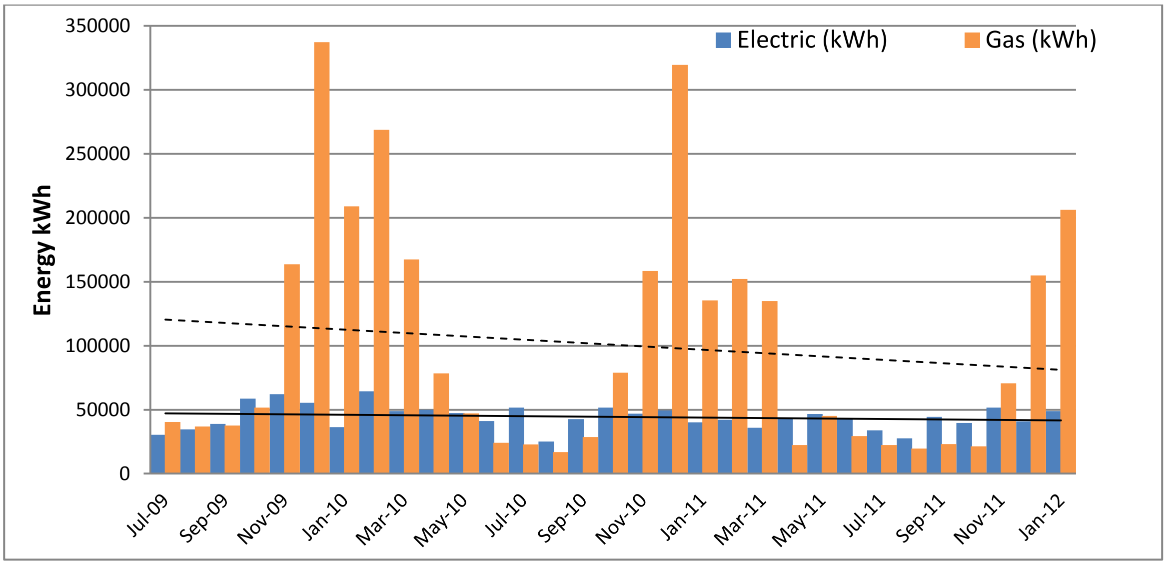


Figure 57. School B: Metered Gas and Electricity (2009 – 2012) (FM data)

Using the half hourly data to create a high resolution picture of electricity demand, each spike on the graph below represents a working week (mon-fri) across the 3 year period. Comparing this daily representation with the monthly equivalent (figure 64) helps to identify particular incidents when consumption suddenly changes. For example, when daily energy consumption exceeds 4000 kWh for example, is this due to malfunction or did the school host a particular event? In addition, there are also instances when the standby levels remain unusually high (October to December 2009 – red line).

Ideally, the BMS system, assisted by the online database should have alerted the FM team to this problem. Unfortunately, due to the various commissioning issues, rapid intervention was not possible. Moreover, problems such as this, left unnoticed, can result in significant financial losses. Thorough and effective commissioning should therefore be seen, not only as way to improve operational efficiency and comfort, but as a pre-emptive strategy to avoid disputes and litigation post-occupancy between the practitioners and/or the client.

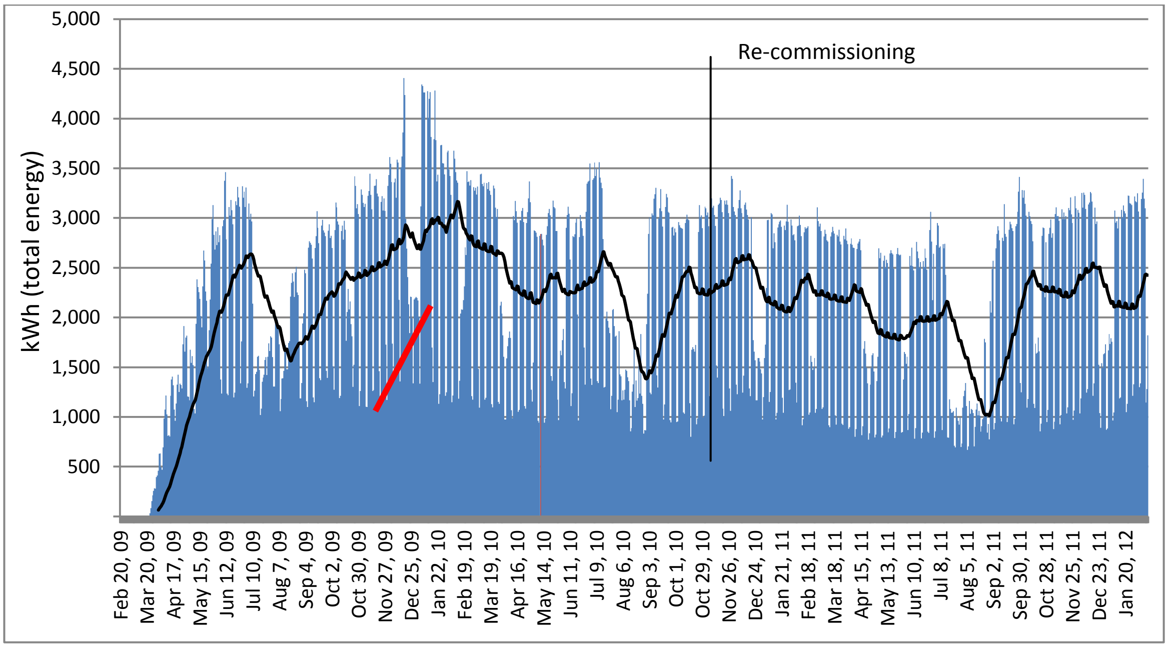


Figure 58. School B: Daily Total Energy (kWh)

In terms of the seasonal demand for electricity, the autumn period, with only a single weeks holiday, consumes on average the most kilowatt hours.

Table 28. School B: Seasonal comparison of Metered Electricity (FM data)

	Summer	Autumn	Winter	Spring	Total
Total	287330	436802	378137	272202	1374471
Months recorded	8	9	8	6	31
Average	35916.258	48533.56	47267.125	45367	177083
Percentage (%)	21%	32%	28%	19%	100%
Months	Jun, July, Aug	Sept, Oct, Nov	Dec, Jan, Feb	Mar, Apr, May	All

Using the metered (FM) data, School B's average electricity consumption was approximately 40kWh/m². Comparing this score with the official DEC figures, the following results were recorded: 2010 = 43 kWh/m²; 2012 = 57 kWh/m², which suggests a rise in electricity consumption.

Looking at the metered data for gas which FM staff collected, the average gas efficiency score was around 90kWh/m². Comparing this with the official DEC figures, the following results were recorded: 2010 = 125 kWh/m²; 2012 = 65 kWh/m², which suggest a fall in gas consumption.

To clarify whether the FM or the DEC data was indeed correct, the half hourly readings were compared (question i).

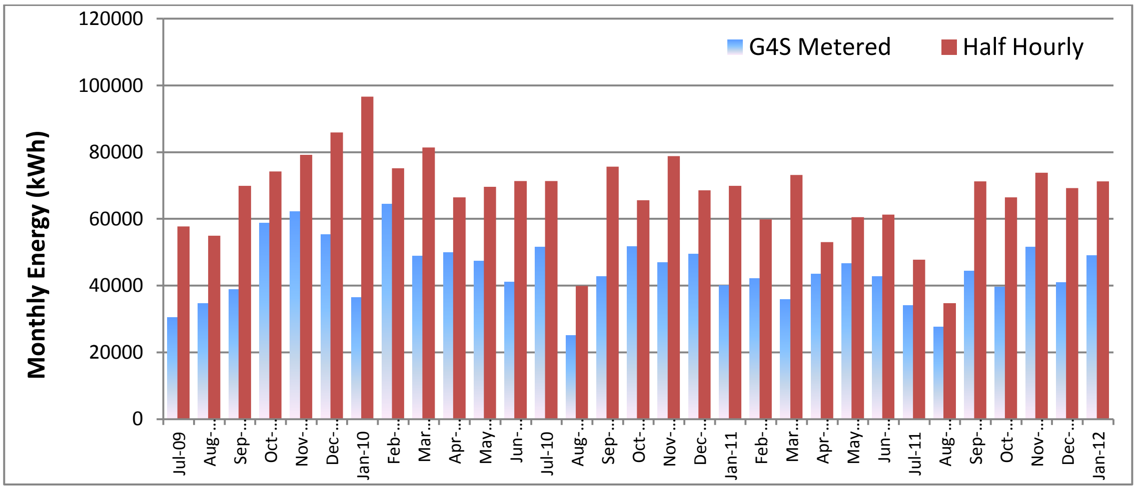


Figure 59. School B: Metered v ½ hourly Electricity data (2009-2012) (35% diff)

It is now clear that the FM provider's metered data was unreliable. Indeed, by totalling up these figures (FM provider = 1,374,471 kWh; HH (Eon) = 2,095,110 kWh) a 35% difference was recorded. In response to question (i) it is possible the metered data may have not included the gymnasium's electricity consumption or indeed another section of the building. Revising the figures using only the half-hourly data, the average ongoing electricity consumption has been calculated as 61kWh/m².

Looking next at water consumption, the trend line shows a gradual decline in consumption, with an ongoing average of 2.29 m³ per pupil. Summer holidays show a clear drop in consumption, with the only other extremity occurring in January/February 2010 when the underfloor heating system malfunctioned and needed all the water to be drained off **[D2]**.

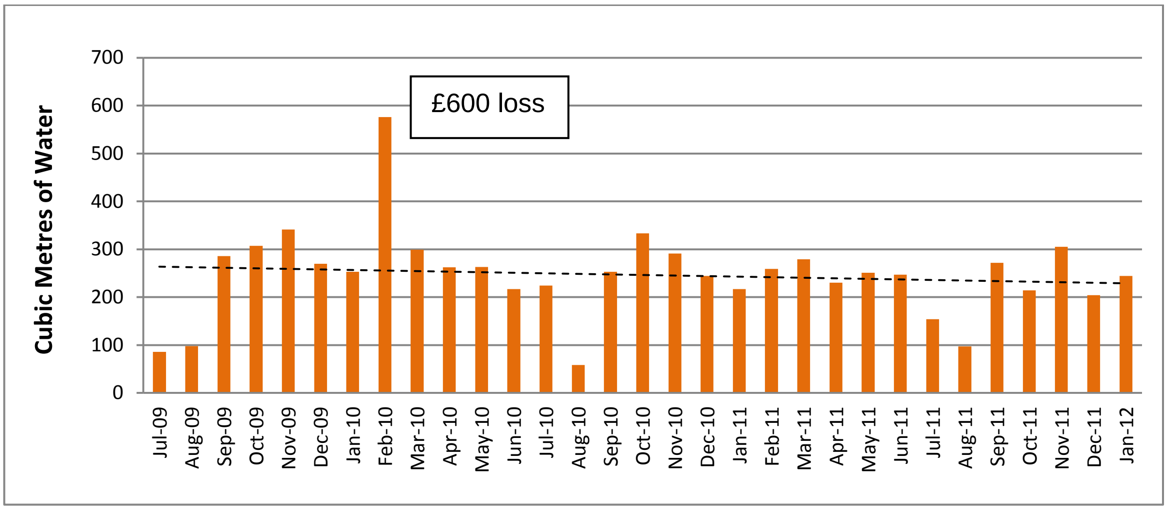


Figure 60. School B Metered Water Consumption (FM data)

From this water bar chart, it is reasonable to assume the building's usage demand has remained stable from July 2009 to January 2012.

6.4.2.1 Half Hourly Data (question iii.)

Looking exclusively at the half-hourly data for evidence of performance optimizations following the re-commissioning audit, we now know from figure 65 how electricity consumption has varied across the 3 years.

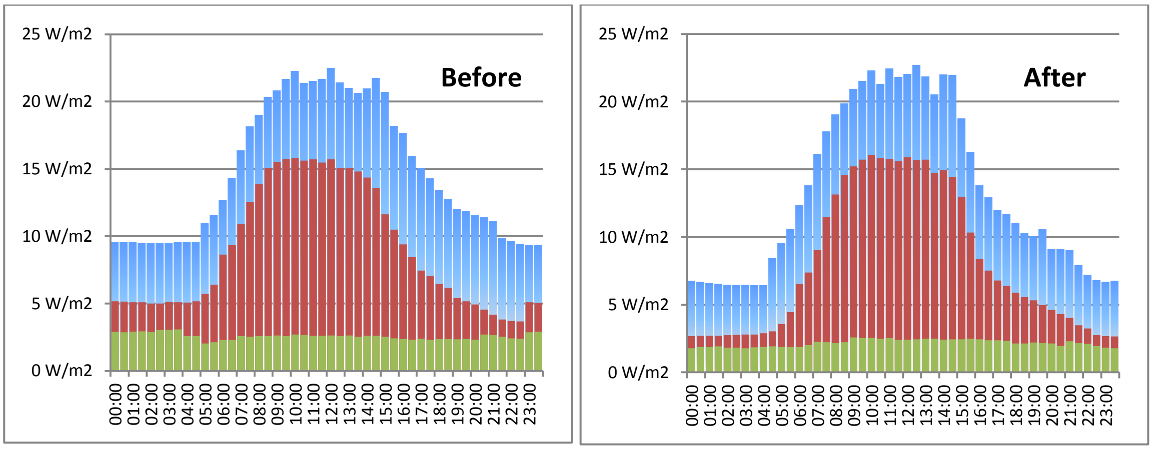


Figure 61. School B Normalised: Before/After Re-commissioning

Looking next at the daily power profiles above, the first significant observation considers the overnight standby periods from 10pm to 4am. Before the re-commissioning, the blue (maximum) and red (average) profiles during this period were approximately 10 W/m² and 5 W/m² respectively. After the energy audit, the standby reduced to around 7 W/m² and 2.5 W/m², evidence to suggest the building was performing more efficiently following the re-commission.

There was also an anomaly on the average (red) profile before the commissioning where the power jumps up at 10pm from 4 W/m² to 5 W/m². This was also in evidence on the weekend profile on the following page. Clearly there was an issue with the control settings prior to the re-commissioning.

Furthermore, the weekend “After” power profile now shows a distinguishable drop in average demand at around 10pm, with the maximum profiles also reducing. Again, as previously discussed at School A and C, examining Saturdays and Sundays separately may shed more light on the pattern of consumption over the weekends. It is possible the buildings are used by the local community on Saturdays but closed on Sundays.

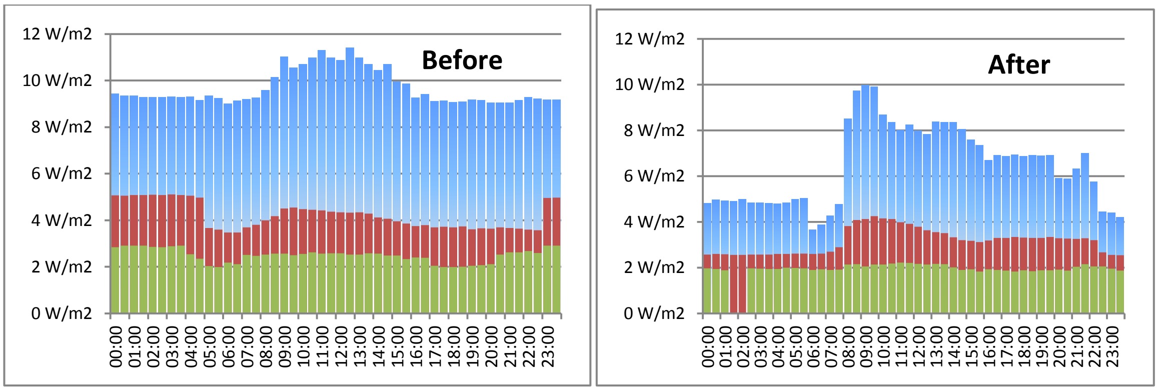


Figure 62. School B HH Electricity Before Vs After Weekend Profiles

It has now been interesting to combine the (half hourly) electricity data with the gas data to produce the following calculations.

Metered Gas: July 2009 to January 2012: Total Energy: 3,125,745 kWh => 574 tonnes of CO_2

HH Electricity: July 2009 to January 2012: Total Energy: 2,095,110 kWh => 1099 tonnes of CO_2

Average per Month: (574 + 1099) ÷ 31 months = 54 tonnes per month

Average per Year: 648 tonnes of CO_2

Ongoing EPI score: 49 Kg CO_2/m^2/pa

By contrast, the 2010 and 2012 official DEC figures calculate that 605 and 557 tonnes of carbon were emitted. It is possible the metered gas figures collected by the FM provider were not 100% accurate but it has not been possible to collect another data set from the utility company to verify these figures.

In responding to question (ii) however, based on the assumption these official DEC figures for gas and electricity are correct, the difference between 2010 and 2012 equates to a 48 tonne efficiency saving. Given that the October 2010 Energy Audit also predicted a 48 tonne carbon saving, it is possible to conclude that the re-commissioning activities were successful.

6.4.3 School C

School C, in the first year of operation was reportedly downgraded from BREEAM ‘excellent’ to ‘very good’ **[D]**. Some of the defects post-occupancy were also causing high energy consumption and overheating problems. Indeed, the reported sum of £10,000 (according to LCC) to re-commission the four schools made the focus on energy efficiency and running costs particular sensitive at School C.

6.4.3.1 Monthly Data

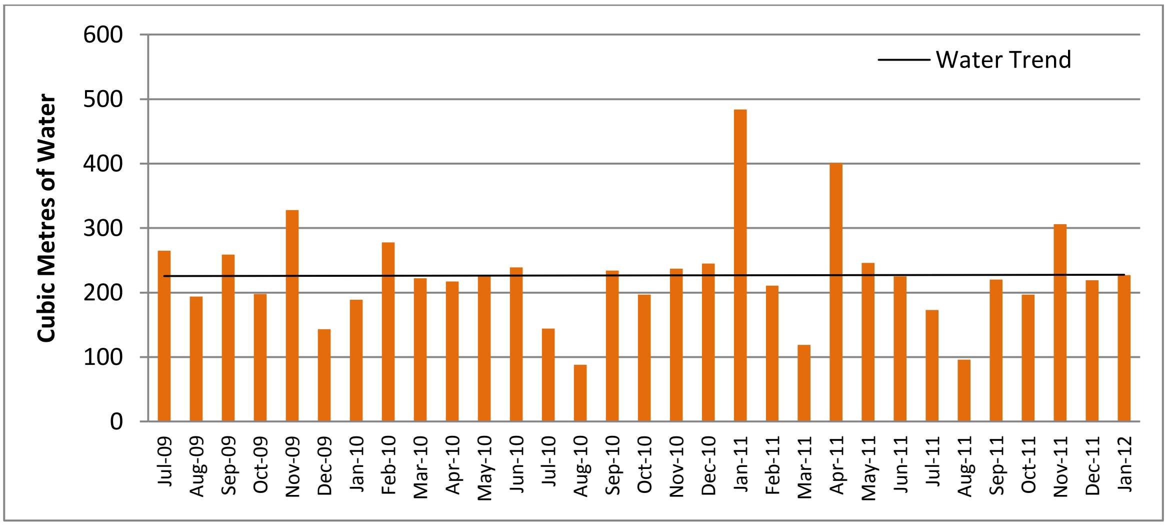


Figure 63. School C Water Consumption (FM data)

Looking at the first three years of metered water consumption, it is possible to see that just over 200 cubic metres of water is consumed per month which equates to 2.27m³ per pupil per year **[D]**. Unfortunately, the existing water benchmark figures do not distinguish between modern and older buildings. As such, School C performs significantly better than even best practice (2.7 m³).

Looking at the seasonal averages, winter (Dec, Jan, Feb) has the highest monthly average of 249.5 litres per month compared with Autumn (242), Spring (238) and Summer (178). Similar to School A, this result suggests that the building is (probably) used more intensely/regularly throughout autumn and winter. It was also noted how a spike in consumption occurred during Dec/Jan 2010/2011. This may explain why average winter consumption was higher than autumn.

Of note was that on two separate occasions consumption rises above 400m³ per month, possibly as a result of maintenance activities relating to the under-floor heating system **[D]**. From a financial perspective, a cubic metre costs in the region of £2.30. These two incidents would have cost the school about £500 each **[E]**.

Looking next at the metered data which the FM provider recorded, gas consumption appears to have risen in the second and third years. This could either be due to colder weather in 2011-2012 (which would then require 'degree day analysis'), or as the researcher suspects, because the biomass boilers were shut down following complaints about exhaust fumes, more gas heating was required **[D]**. At the same time, electricity consumption was relatively constant. This may reflect minimal uptake in communal and extra-curricular activities **[B].** Alternatively, operational improvements **[D]** following the re-commission may have offset any increase in building usage.

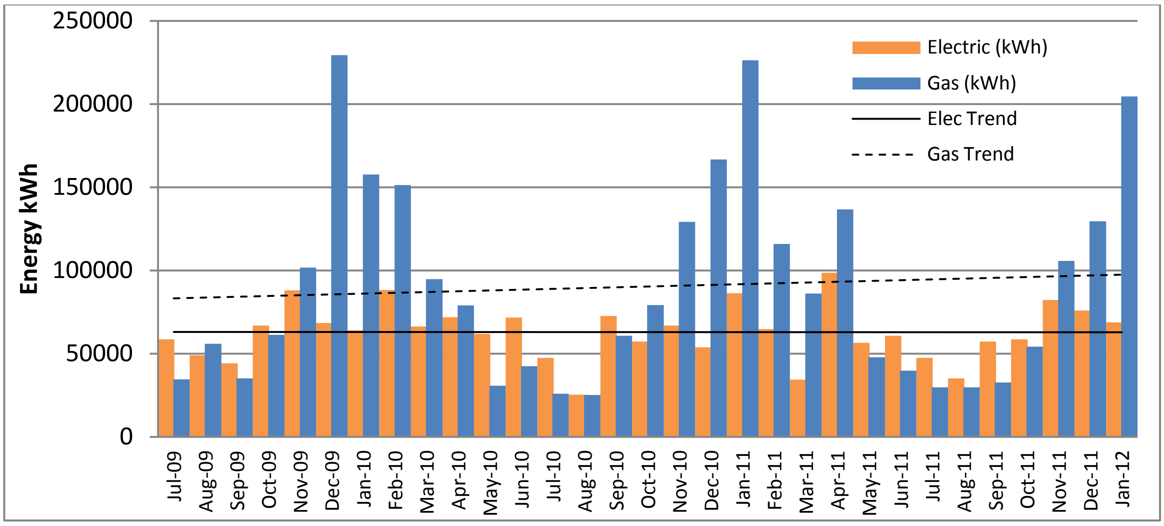


Figure 64. School C: Metered Gas and Electricity (2009 – 2012) (FM provider's data)

In relation to the electricity benchmark of 40kWh/m², School C averaged around 63kWh/m²/pa.

In terms of gas consumption, once the readings had been converted from cubic metres (m³) to kilowatt hours (kWh), normalised gas consumption (per m²) was found to be approximately 90kWh/m²/pa, substantially lower than the CIBSE target value of 150 kWh/m²/pa.

NB. Nationally the strategy to reduce emissions from electricity begins with de-carbonizing the supply and improving the delivery efficiency of the national grid. The focus of this research looks *specifically at the pattern of end-use consumption. It was therefore interesting to note how BREEAM's predicted design analysis does not consider the use of electrical appliances such as "white" goods and ICT as part of the assessments. Evidently, closer collaborations at the design stage will be necessary if or when the regulations demand that energy predictions take into account every aspect of energy consumption.*

In terms of the environmental impact, School C was producing 594 tonnes of CO_2 per year, equivalent to 50 kg CO_2/m²/pa. At the same time, the inclusion of biomass should aim to reduce this amount by up to 22% in order to ensure the aggregate savings across phase one equate to a 11% saving per school.

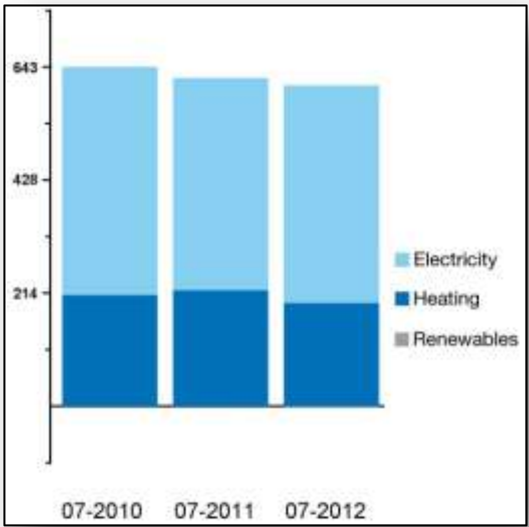


Figure 65. School C 2012 DEC Extract

As far as energy reduction was concerned, the 2012 DEC suggests a marginal decline in overall emissions, with year one producing 643 tonnes of carbon. However, the FM team's monthly gas data does not validate this decline. Indeed, with biomass consumption also declining during this period, an overall rise in emissions may be expected. It has therefore been necessary to examine both the FM provider's monthly metered data with Eon's half-hourly electricity data.

6.4.3.2 Half Hourly Data (question iii.)

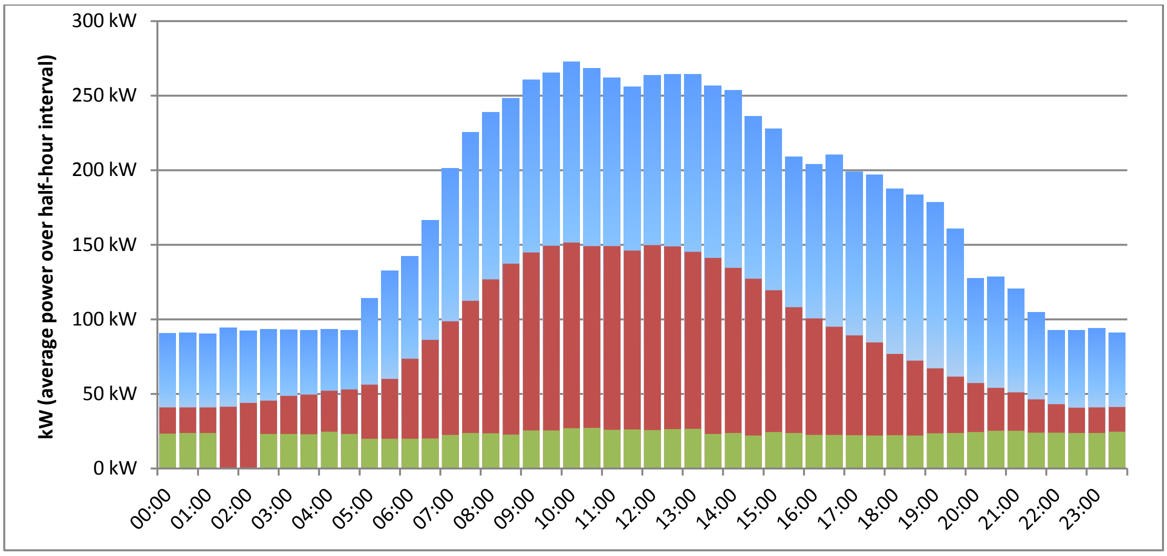


Figure 66. School C Power Profile: 2009-2012 (Mon-Fri)

Looking next at the half-hourly electricity data, the three year profile graphic confirms how the average peak load demand for electricity (150kW) was 17% higher than School A (125kW) which reflects the fact that School C has 12.5% more students (1200 vs 1050) and a 12.5% more floor space (12,000m² vs 10,500m²) compared with School A .

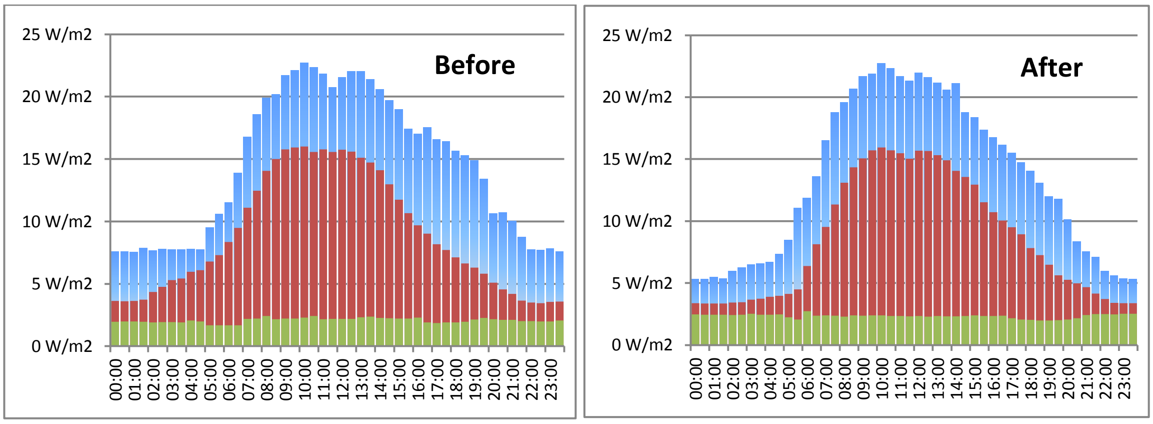


Figure 67. School C Normalised: Before Vs After Commissioning (Mon-Fri)

Looking now at the normalised (per m²) weekday electricity profile before the re-commissioning, it was noted how the standby demand of 4 W/m² was interrupted at 2am, gradually rising throughout the morning to 15W/m². In contrast, the power profile after the re-commissioning remains fairly constant throughout the night from 10am to 5am. Judging by the steepness of the curve from 5am to 10am, a faster start-up setting has allowed the school to operate more efficiently. In other respects, both profiles remain broadly the same. Evidently the modifications carried out during the energy audit have marginally improved the operation of the building **[D]**.

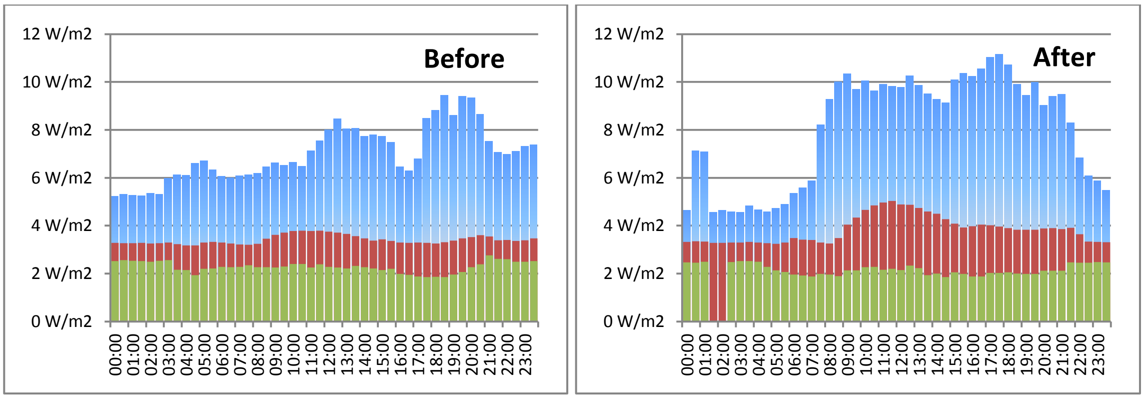


Figure 68. School C Power Profiles: Before Vs After Commissioning (Sat-Sun)

Looking at the weekend consumption profiles above reveals a more turbulent picture following the re-commissioning. In fact, energy consumption appears to have increased slightly. However, it is not clear how best to interpret the (blue) maximum profiles as they represent infrequent extremes in demand. Indeed it seems there is now a perceptible shape from 8am through to 3pm following the re-commission, suggesting the building is now in use by the community. Further analysis to separate Saturdays from Sundays may help to clarify this situation as previously highlighted at School A.

Finally, in response to question (i), comparisons between the manual meter readings and the half hourly data can be seen to vary only slightly. Analysis of total consumption during this period further validates the reliability of both data sets as there was only a 1% difference (metered FM data = 1,842,036 kWh; half hourly = 1,846,959.2 kWh).

It is therefore not 100% clear why the 2012 DEC indicates a gradual decline in emissions. However, by adding a trend line to the half hourly electricity data (see figure 62), you can see that electricity consumption has gradually declined over the past three years, mirroring the light blue bars on figure 58.

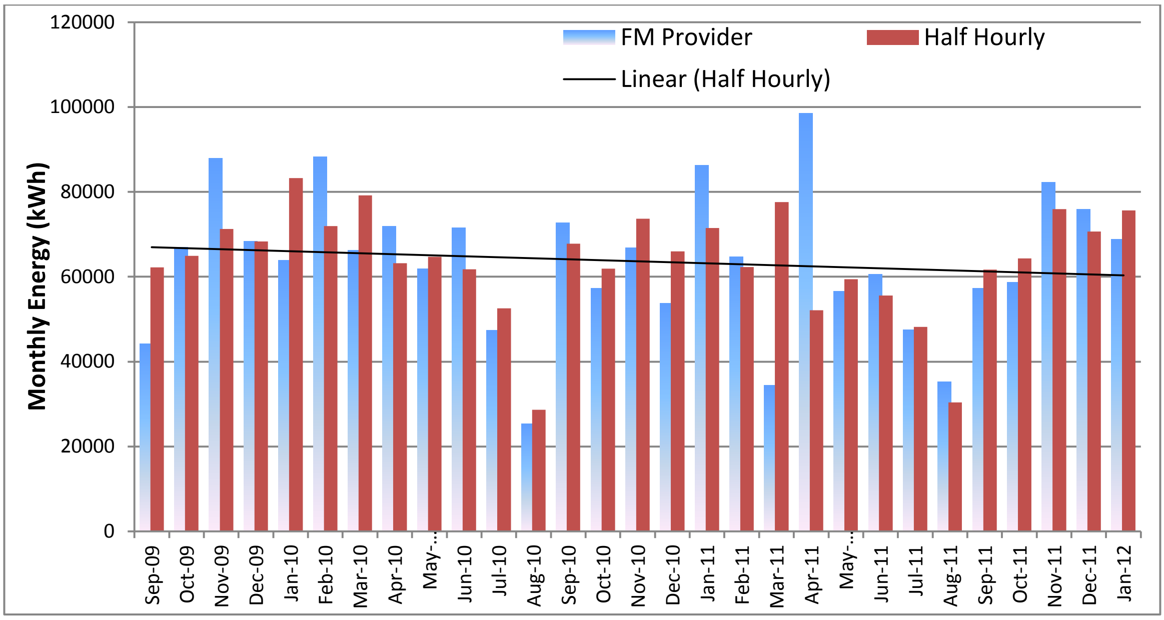


Figure 69. School C: Metered v ½ hourly Electricity data (2009-2012) (<1%diff)

To address question (ii), the re-commissioning report predicted an annual saving of 39 tonnes of CO_2, with a further 24 tonnes of “potential” savings possible should further upgrades be carried out **[D]**. In the light of the biomass issues, from September 2009 to 2010, emissions ran at 640 tonnes of CO_2 based on the FM gas and electricity data, (excluding biomass). A year later, using the same FM data, from October 2010 to 2011, this had fallen to 624 tonnes, a fall of approximately 16 tonnes of CO_2.

This marginal reduction of 2.5% demonstrates the challenge presented at School C in terms of reducing energy consumption. Moreover, with the biomass out of action for an extended period of time, it was inevitable that gas consumption would increase.

Based on this evidence, until such time as the upgrades have been carried out and the biomass system has been properly commissioned, the true energy efficiency of the new School C building remains unclear.

More generally, this particular case-study highlights the problems associated with constructing and commission a complex building when the deadline for completion cannot be extended.

6.4.4 School D

As a refurbishment project the possibilities to improve energy efficiency were limited since it was only possible for the Trend (BMS) engineer to identify a single tonne of carbon savings. However, the audit report was able to identify a further 10 tonnes of savings if further upgrades were to be carried out.

6.4.4.1 Monthly Metered Data

Looking first at water consumption, the monthly meter readings indicate a gradual reduction in water consumption. It was also observed how the figures for the meter reading suddenly changed from October 2010. Either there was a substantial leak (19,423 cubic litres => £25,000), or a different meter was used to record monthly water consumption.

July	August	September	October	November	December
5,777	5,858	6,042	25,465	26,280	26,400

Source: FM data

As a result of this problem, October and November 2010 were removed from the data set to maintain continuity.

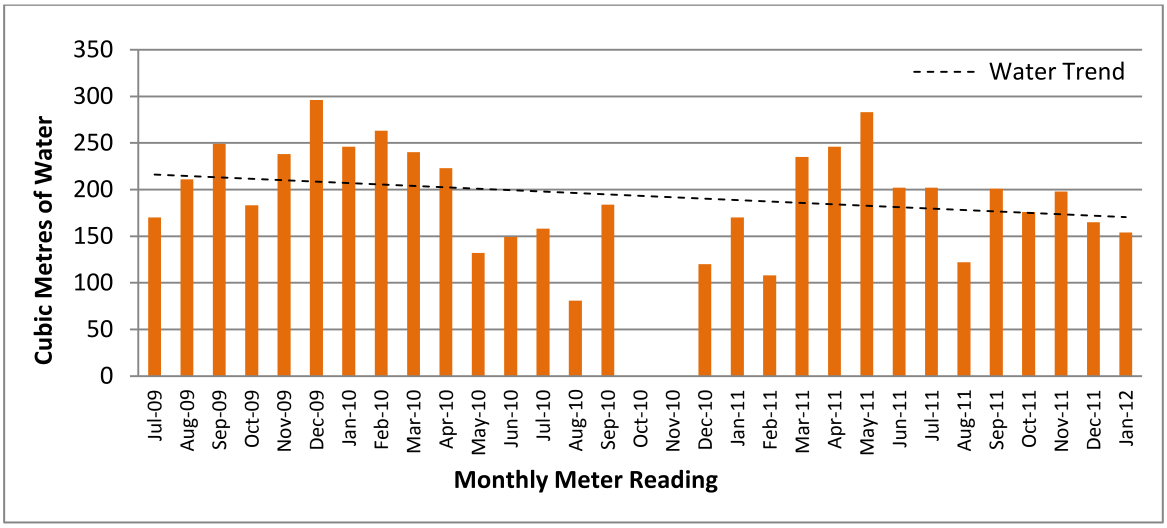


Figure 70. School D: Monthly Water Consumption

It was also interesting to note that average water consumption was 2.57 cubic metres (m^3) per pupil per year, marginally higher than the three new build schools which consumed in the region of 2.3m^3 per pupil per year. It was also discovered during the collection of DEC certificates that School D's gymnasium, built in 2004, had its own BMS system which managed gas and electricity separately from the main building. However, it was not clear at this stage whether water consumption was also metered separately.

Main heating fuel: Natural Gas
Building Environment: Air Conditioning
Total useful floor area (m^2): 1205
Asset Rating: Not available

	Heating	Electrical
Annual Energy Use ($kWh/m^2/year$)	755	215
Typical Energy Use ($kWh/m^2/year$)	377	108
Energy from renewables	0%	0%

Figure 71. School D Gymnasium: DEC (2009)

The 2009 Gymnasium DEC also highlights how this separate building had the worst energy rating of "G". Indeed, the normalised figures confirm the high intensity of energy consumption in the gymnasium.

Looking now at the main building's 2012 DEC, the difference in performance ($kWh/m^2/year$) between the two buildings are considerable. Simply by comparing these values, the gymnasium uses approximately 10 times more electricity and 3.5 times more gas per metre square.

Main heating fuel: Natural Gas
Building Environment: Heating and Natural Ventilation
Total useful floor area (m^2): 10500
Asset Rating: Not available

	Heating	Electricity
Annual Energy Use ($kWh/m^2/year$)	70	59
Typical Energy Use ($kWh/m^2/year$)	183	59
Energy from renewables	0.0%	0.0%

Figure 72. School D Main Building: DEC (2012)

Looking now at figure 73 on the following page, gas consumption would normally be expected to rise substantially in winter as previously seen with other three schools. This was not the case. In fact, the researcher has deduced that because the gymnasium was metered separately for gas and electricity, figure 73 is representative of the building alone.

It has also been noted how both gas and electricity consumption in the main building gradually fell according to these figures collected by the FM provider, with carbon emissions estimated to be approximately 400 tonnes per year, equivalent to 38kg CO_2/m^2/p.a.

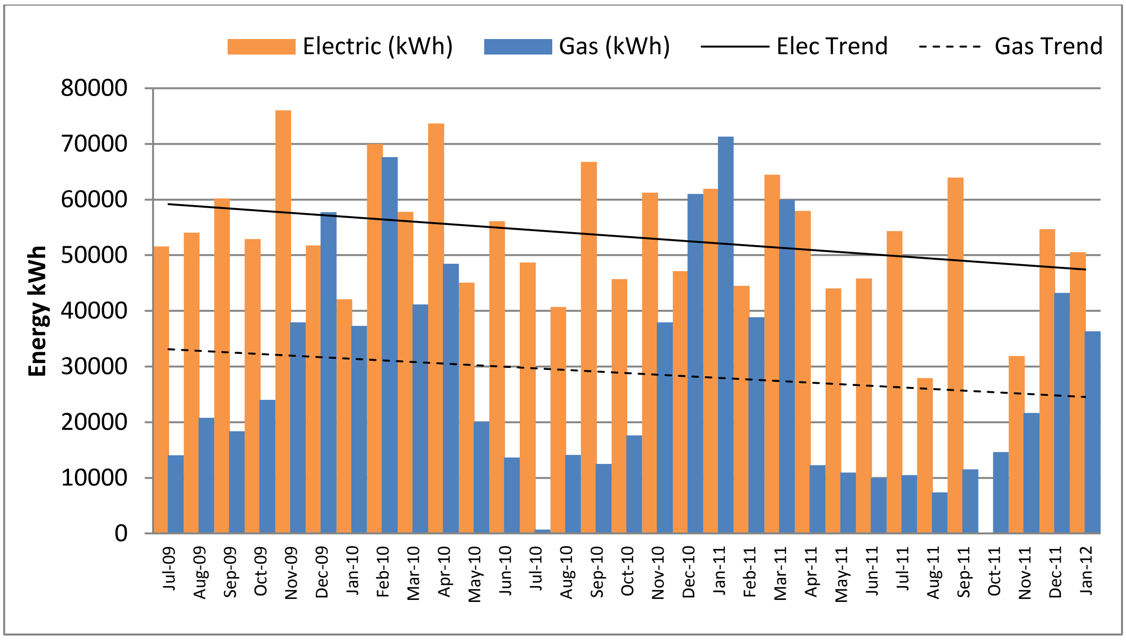


Figure 73. School D: Monthly Metered Gas & Electricity Data (2009-2012) (FM data)

However, by including the gymnasium contribution based on the 2009 DEC data (floor area = 1205m²), total emissions for the entire facility rise to around 600 tonnes per year.

Examination of the FM electricity data also reveals another continuity problem in October 2011.

July	August	September	October	November	December
1,735,767	1,763,713	1,827,670	19,387,709	19,419,632	19,966,212

Source: FM data

Furthermore, according to the official 2012 DEC data, the main building had a normalised electricity and space heating performance of 59 and 70 kWh/m²/per year respectively. This compares with the FM data which recorded 61kWh/m² for electricity and 33kWh/m² for gas.

It has now been necessary to use the half hourly data to validate the FM electricity data and to determine whether the gymnasium's consumption has again been excluded from both data sets.

6.4.4.2 Half-hourly Data

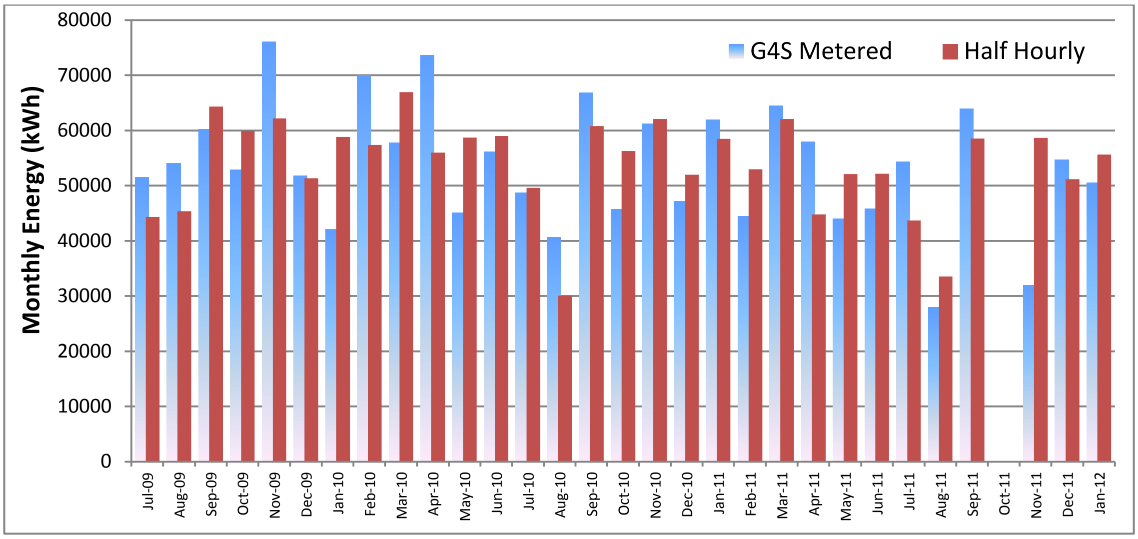


Figure 74. School D: Metered v ½ hourly Electricity data (2009-2012) (<1%diff)

As figure 72 illustrates, both metered and ½ hourly electricity data have been compared. From July 2009 to January 2012, the metered data totals 1,603,376 kWh, compared with 1,618,868 kWh for the half-hourly data, (a difference of 1%). Given the similarity of these two data sets, it is reasonable to assume both sets are reliable and correct. It also confirms that both the metered data and the half hourly data do not include the gymnasium's electricity consumption.

Looking at both figure 75 and 76 on the following page, these weekday profiles (which exclude the gymnasium's electricity usage), reach their standby level of approximately 5 W/m² at 6pm. It can also be observed how peak power from 9am to 1pm has actually increased from 14 W/m² before the re-commissioning to around 15 W/m² thereafter. At the same time, the average standby demand has marginally reduced from 5 W/m² to 4.5 W/m².

These results indicate how the building is now operating more intensely during the day, and slightly more efficiently during the night following the re-commissioning adjustments. However, the maximum blue profile remains broadly the same, (possibly) suggesting the building's energy demand variance could still be reduced to improve overall efficiency.

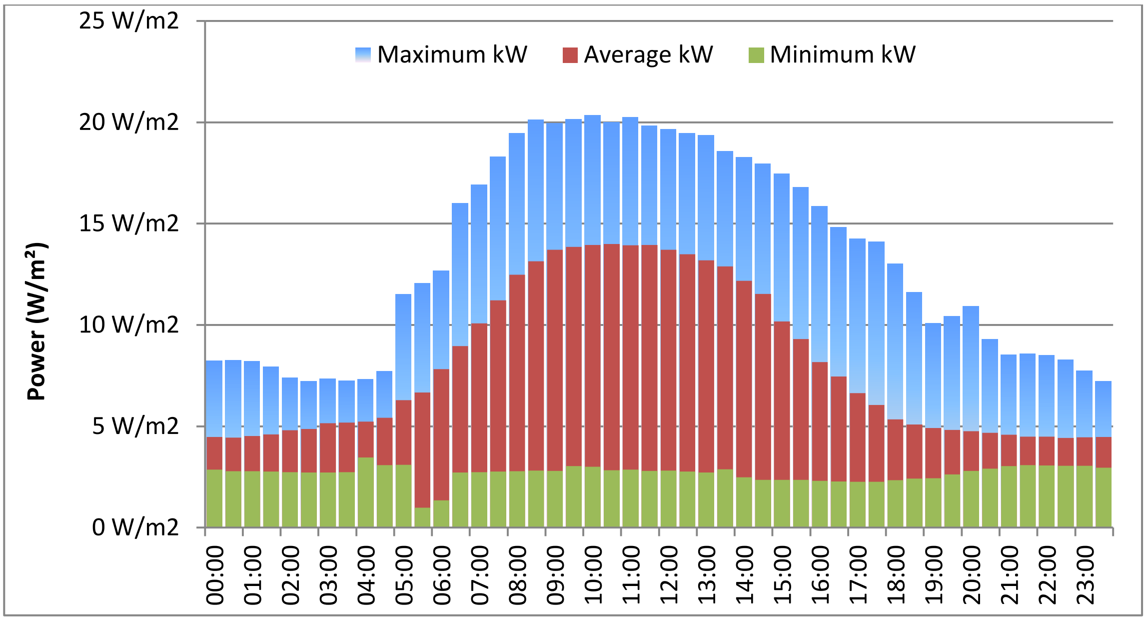


Figure 75. School D: HH Electricity Profile Mon-Fri Before Re-commissioning

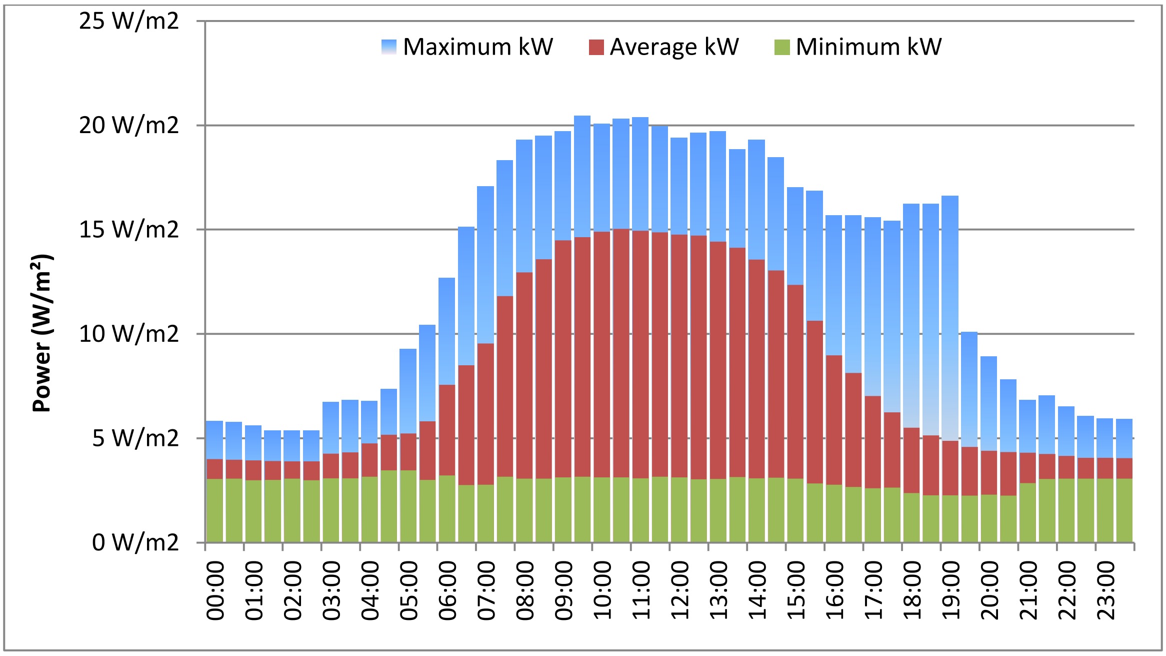


Figure 76. School D: HH Electricity Profile Mon-Fri After Re-commissioning

In 2010 and again in 2012, the DEC certificates rated electricity performance at 64 and 59 kWh/m² respectively. To validate these official figures, average performance using the half-hourly data was approximately 61 kWh/m².

In 2010, the gas DEC score was 107kWh/m² which then fell to 70kWh/m² in 2012. However, whilst the metered data demonstrates a consistent decline (figure 73), the data appears to represent only a proportion of the building since average consumption was calculated at only 33 kWh/m², substantially lower than the DEC figures.

As a result, calculations for the carbon emissions relied exclusively on the data contained on the DEC certificates.

School D: MAIN BUILDING - (DEC, 2012)

Floor area: 10,500

Electricity: 59 kWh/m²/per year

Gas: 70 kWh/m²/per year

Total kWh in 2012: (10500*59) + (10500*70) = 619500 + 735000 = 1354500 kWh

Associated Electricity Emissions: (619500*0.5246 ÷ 1000) = 325 tonnes of CO_2

Associated Gas Emissions: (735000*0.1836 ÷ 1000) = 135 tonnes of CO_2

School D: Total "Main Building" Emissions (2012): 460 tonnes of CO_2

School D: GYMNASIUM - (DEC, 2009)

Floor area: 1,205

Electricity: 215 kWh/m²/per year

Gas: 755 kWh/m²/per year

Total kWh in 2009: (1205*755) + (1205*215) = 909775 + 259075 = 1168850 kWh

Associated Electricity Emissions: (259075*0.5246 ÷ 1000) = 136 tonnes of CO_2

Associated Gas Emissions: (909775*0.1836 ÷ 1000) = 167 tonnes of CO_2

School D: Total "Gymnasium" Emissions (2009): 303 tonnes of CO_2

The total consumption for School D using the above calculations based on a combined floor area of 11,705m² was 760 tonnes of CO_2 per annum, equivalent to 65 kg/CO_2/m² which is considerably higher than the three new build schools using the same DEC figures.

Table 29. 2012 EPI Scores (*) Excluding Biomass Consumption

	School B* (13,300m²)	School A (10,700m²)	School C* (12,000m²)	School D (11,705m²)
Normalised	42 kg/CO_2/m²	46 kg/CO_2/m²	49 kg/CO_2/m²	65 kg/CO_2/m²
Total	556 tonnes	496 tonnes	589 tonnes	~760 tonnes

Source: DEC (2012)

The first conclusion that can now be drawn from table 30 is the clear difference in normalised efficiency between the three new build schools and School D. The second point would be to highlight the large emissions associated with the gymnasium facility. Indeed, as School D's half hourly power profile illustrates, use of the main building did not extend beyond 6pm. By contrast, the Monday to Friday power profiles of the three new build schools powered down more slowly, presumably because the gymnasiums were in use until 10pm.

More generally the after effects from the re-commissioning demonstrate why onsite expertise is required on a regular basis to modify the controls to ensure optimum operation. To help achieve this level of efficiency, the software needs to control the hardware via the 963 computer terminal. The inability to control specific zones throughout the building was a particular problem identified. Lighting, heating, ventilation and air conditioning were all services which needed to be scheduled tightly around occupancy requirements.

The BMS system should also alert maintenance staff to instances when particular thresholds of consumption are breached. At School B for example the initial weekend power profile illustrates how systems were not powering down as they should. Furthermore, with the online database out of action, the schools were reliant on the FM provider to manually record meter readings. In some instances data continuity became an issue highlighting the need for an online system to be in operation.

Chapter 7 Educational Transformation

*This section examines the evidence which links to the educational **[A]** and community **[B]** "dimensions" of the sustainable schools matrix. Furthermore, a longitudinal evaluation of the available data has enabled the researcher to examine 10 years of data (2002-2012).*

Four types of analysis have thus been identified;

1. Review of contextual documentation:
   Sources of secondary data: Ofsted reports, School Prospectus, School Websites, local news media etc.
2. Review of Education Performance:
   Sources of secondary data: GCSE results, Attendance Data, SEN data, FSM data.
3. Review of Parental Perceptions:
   Source of secondary data: Ofsted Reports.
4. Evaluation of Staff Satisfaction:
   Source of primary data: "Occupancy" Questionnaire Survey.

7.1 Review of contextual documentation

This first section focuses on the historical evidence (1) which the researcher has been able to gather over the past 3 to 4 years.

7.1.1 School A

Key extracts have been taken from the 2011/2012 prospectus which help demonstrate the important contribution the new building is making both for the school and the local community.

> *"In November 2009 we won BSF School of the Year and the overarching Grand Prix Award at the annual Partnerships for Schools Excellence Awards. We were chosen from*

120 projects because of how we had worked with students to raise achievement ***[A]****, improve behaviour* ***[B]*** *and transform our culture* ***[B]****",*

"We did well in our old school but in our new school we are really flying! However, no school can be successful without students, staff and parents working together ***[B]****. We have given students more responsibility and freedom in the new school but we have also raised our expectations of them in relation to behaviour and effort, and we expect parents* ***[B]*** *to support us in maintaining high standards in both",*

"We are fortunate to have wonderful new facilities ***[D]****. In order to make good use of these facilities, and make them available to the community, we have gone into partnership with an organisation called Kajima* ***[B]****. Kajima have been working hard to market the school and to attract groups and organizations to make use of the building. We are very pleased with how well the facilities are being used and by the range of activities on offer..."*

NB. BSF schools were intended to operate more like "community" centres, helping to regenerate social deprived neighbourhoods

Contrasting these statements with the 2002 Ofsted Report helps to gauge the scale of improvements following the BSF investment. First of all, the inspector highlights the socio-economic challenges facing the school **[B]**.

"*A significant number of students are from low socio-economic backgrounds. Unemployment in the area is above the national average and the number of students eligible for free school meals is above the national average"* (Ofsted, 2002, p.6)

In addition, the language skills of children from ethnic minority backgrounds was a factor which made the teaching and learning process more challenging **[B/A]**,

"*Attainment on entry to the school is below average... around a quarter of students come from ethnic minority backgrounds, with around half of these having English as an additional language"* (Ofsted, 2002, p.6)

In the old school, ICT resources were singled out as “inadequate” **[D]**. The report also explains how teachers are not able to identify where the application of ICT would enhance students' learning **[A]**. At the same time, students were regularly using the library's ICT resources outside of class.

Even in 2002, the inspector felt it necessary to highlight emerging environmental challenges which students discussed **[A/C]**,

> “*Geography challenges students with issues relating to the environment, population and development... students want to learn and this shows in their curiosity about the topic. For example, a student was keen to explore the effects of changes to our climate if global warming accelerates... and this was seen when they prepared presentations on wind farms... When discussing why it would be difficult to stop the world burning fossil fuels, a student with special educational needs (SEN) answered that all countries would not, because they need to industrialise” (Ofsted, 2002, p.21)*

As far as the old building was concerned, the report identifies that a lack of equipment in subjects like technology, *“limits the development of knowledge and understanding”* **[A]**. Social spaces like the dining area were also singled out as *“unsuitable for many activities taught there”*. Health and safety issues in the technology workshops due to poor air quality were also identified.

By 2007, the Ofsted Report had been revised. As a result the report was substantially more concise, focusing less on the detail of subject departments and more on the well-being of students throughout the school. Assessing the school's contribution to the local community was now seen to be an important part of the assessment process. As a result, it was important for senior management and the governing body to articulate their aims and objectives in response to the “extended schools” initiative which the government was promoting at the time.

Ordinarily, schools have traditionally been closed from 4pm onwards during the week. BSF schools by contrast, with help from organizations such as Kajima,were expected to extend their opening hours so they could deliver a wider range services to the local community. Inevitably however, this extended use has important implications for the energy consumption. Electricity in particular has become a resource that provides many of the services which rely on ICT provision.

From an educational perspective, the 2007 report explains how “considerable staffing turbulence” had detrimentally affected GCSE examination results in 2004 and 2005 **[A]**. At the same time, the head teacher’s capacity to manage and motivate her staff was central to the school’s resilience when faced with challenging circumstances.

> “*The head teacher has taken a very strong and effective lead. She has a clear strategic vision for the school and how it should develop as an inclusive community where students can achieve their full potential. She is unequivocal about the responsibilities of all staff for implementing this vision and has been effective in developing leadership at all levels in order to achieve consistency and sustainable improvement” (Ofsted, 2007, p.7)*

Looking finally at the most recent Ofsted report (May, 2010), the inspector confirms how the new building was awarded first prize in the 2009 BSF School of the Year competition, explaining how this ‘... *has had a positive impact on the school ethos and behaviour and has transformed the school environment.” (Ofsted, 2010).*

Indeed, with the new facilities providing a wide range of activities and entertainment for students, behaviour was now seen to be improving. Furthermore, with students spending more of their recreational time in the new building, older year 10 and 11 students were now helping to support year 7 pupils.

The 2010 report also identifies how incidents of bullying had decreased since the new building had opened in September 2009 **[B]**. All in all, the new building has made an immediate and positive impact on all aspects of school and community life based on the evidence presented within the Ofsted reports.

7.1.2 School B

The 2001 Ofsted report describes the demographic make-up of the students which, more or less, reflects the prevailing circumstances today in 2013 **[B]**.

> "*Four fifths of the students are of Indian origin, many of whom are fourth generation British Asians. The biggest minority group in the school is white and there are small numbers from a range of different ethnic backgrounds... the proportion of students with special educational needs is above average **[A]**... when students join the college their attainment is below average **[A]**." (Ofsted, 2001, p.7)*

In terms of the building itself the report identifies "unsatisfactory accommodation" for English, Design and Technology, Modern Languages and Physical Education. The school also had a public pathway crossing through the campus, resulting in dog fouling **[B]** and on one occasion, a burnt out car was left in the middle of the games field **[B]** highlighting the need for better security in the new building **[D]**.

The 2001 report was also critical of the governors' inability to articulate where the school's strengths and weaknesses lay **[A/B]**. Moreover, the inspector points out how the school failed to keep parents properly up to date about local news events and activities **[B]**. This failure to communicate with the local community may explain why only 48 Ofsted questionnaires were completed by parents in 2001.

At this point in time, it was evident that the school's ethos and identify were not clearly defined. In addition, the report explains how,

> "*Since the last inspection (1996), the evidence at first is of decline in the standards being achieved by the college. Latterly, the evidence is of a turn-around in what is being achieved. The decline showed in two major ways. GCSE results fell each year so that the college no longer achieved results that were above the national average **[A]**. Internal difficulties in the governing body resulted in the need for external support in reconciling different viewpoints in order to enable the work of the governing body to properly*

> *continue... There have been many staff changes **[B]** during this period and a number of changes in the membership of the governing body" (Ofsted, 2001, p.26)*

By 2007, a new Head Teacher was appointed. Bringing a traditional approach to school leadership, his appointment signalled the beginning of a new chapter where expectations were higher in terms of attainment, behaviour and competitive sport. By 2010, the Ofsted report explains,

> "*... since the last inspection (2007) there has been tangible progress in raising attainment, attendance and improving quality of teaching and learning in departments where students were not progressing as well as they might **[A]**. The positive outcomes from improvements in recent years demonstrate School B's good capacity for sustained improvement." (Ofsted, 2010)*

Looking at the 2011/2012 prospectus for further evidence of a change in culture **[B]**, it was noted how a setting policy **[A]** across the major subjects during years 7, 8 and 9 was now in operation. At the same time, Ofsted rated the school's pastoral care system **[B]** as "outstanding" where for example form tutors remain with their classes throughout the 5 years.

Indeed, whilst the 2010 Ofsted report makes little mention of the new building, the researcher felt that the decision to locate the cricket pitch in front of the new building was an intelligent and appropriate gesture to the local, mostly Indian, community **[D/B]**. Furthermore, in light of the past instances of anti-social behaviour **[B]**, a security fence was erected around the school grounds to improve security and deter criminality.

7.1.3 School C

The 2002 Ofsted report describes the old 1970s clasp building as “unsatisfactory, small, crowded and congested” **[D/C]**. For example, in summertime, the school was forced to suspend lessons in particular mathematics classrooms due to overheating **[A]**.

The report also confirms how approximately 60% of the students do not speak English at home **[B]**. As a result, literacy skills of year 7 children were below the national average **[A]**. 5 years on from entering the college in year 7 however, year 11 GCSE results were above the national average, highlighting the school’s ‘value added’ contribution.

Moreover, with approximately 1,200 students in attendance, the old building only had a single dedicated ICT room without external windows **[D]**. This meant that teachers and students were put off from using this facility. It was therefore interesting to note how the BSF programme prioritised ICT as a central part of its transformation agenda.

By 2007, improvements to the ICT infrastructure were recognised by Ofsted. At the same time, the school had recently become a ‘Specialist Language College’, providing evening classes for the wider community. It was also pointed out that permanent and fixed term exclusions were in decline. In this regard, the Ofsted inspector explains how the head teacher’s,

> *“... vision and energy are central to the success and popularity of the college in the community **[B]**”. (Ofsted, 2007,p.4)*

In 2009 Ofsted carried out a brief inspection of the new languages building, making the following observations,

> “*Teaching ensures that students are stimulated by lively and engaging resources. This results in high levels of motivation. Games and successive lively activities ensure that students maintain concentration; not a moment is lost and students learn to their maximum potential **[A]**... Accommodation and resources are excellent **[D]**, and destined to become even better when the school’s new building opens shortly. All rooms are equipped with interactive whiteboards and there is a dedicated multi-media room for languages **[D]**... All teachers in the language team use electronic whiteboards to present new language and activities. Most use this facility in innovative and highly creative ways,*

enabling students to work interactively and develop their understanding of language in challenging, fast-paced and very enjoyable ways." (Ofsted, 2009)

More recently, the 2010 Ofsted report highlights the focus on developing foreign language skills as an example of the school's more recent success,

"... *63% of students gain at least one GCSE grade A* to C in a modern foreign language, significantly above the national level of 28%..* ***[A]****." (Ofsted, 2010)*

It would seem that the new languages block was helping to raise teaching standards **[A]**. Indeed, by the time the new building was completed, the school received the highest grade of "outstanding" (grade 1) by Ofsted **[A/B]**. Furthermore, the multi-cultural heritage of the school's population also served as a mechanism through which to promote community engagement **[B]**,

"*... the promotion of community cohesion is central to the college's ethos and is reflected in the exceptional sense of identity and tolerance across the college. This is a longstanding feature of the college and has gained national recognition... the college holds awards for Investors in People and Healthy Schools." (Ofsted, 2010).*

The extent to which a school is oversubscribed is often seen as a proxy indicator for the way parents regard a school. According to the 2011/2012 prospectus, School C was oversubscribed by 829 applications to 240.

Comments made by the business manager also help to explain how the new building **[C]** has improved the quality of life more generally **[B3]**.

".. *most of the staff here… feel that our vision we first started with, we have actually got. What we thought it would do educationally, the environment for students, we believe we have 95% got there, we have the wide corridors, natural light, we've got topography of the land* ***[D]****... we have a low turnover of staff* ***[B]****, ... we feel we have a great team here and we have received outstanding from Ofsted* ***[A]****, and become one of the top 20 schools for behaviour in the country* ***[B]****... but it's definitely had an impact on education* ***[A]*** *in terms of interactive white boards* ***[D]****, so lessons are better, socially the environment has become a nice place to work and the majority of students come from inner city areas* ***[B]****… so they feel safe, lots of green areas..." (School C Business Manager, 25th May 2010)*

7.1.4 School D

Similar to the new language block which was built at School C, as a precursor to the refurbishment of the existing building, School D was fortunate to have a new gymnasium built in 2003. In a report conducted by Loughborough University, in order to assess the full impact of the new sporting facility, students and teachers were interviewed and their comments recorded. Notable observations from this analysis have been presented on the following page.

Previously, PE was restricted to 30 minutes per week. Now most year groups benefit from at least 2 hours of PE per week. The report also identifies how in the past,

> "*Recruiting PE staff has been difficult because it is an inner city school **[B]** with very poor facilities **[D]**..." (Loughborough University Report)*

Previously, ordinary classrooms were (occasionally) used for PE lessons. Since the new gymnasium, boys and girls attend separate PE lessons **[B]**. The new changing rooms **[D]** have also created an environment that has dramatically increased the take-up of sport by female students **[A/B]**.

The gymnasium was also allowing the school to compete in local leagues and competitions **[B]**, at the same time as creating a revenue income **[E]** from renting out the facility to local clubs, including the Leicester Riders, a professional basket ball team. However, the report does acknowledge that some students felt annoyed by the fact that the gymnasium was hired out to the general public. Furthermore, when visiting teams came to play in competitive matches home fans behaved abusively. As a result, these students were banned from supporting the school in any future competitions. Unfortunately, this incident was symptomatic of the wider behavioural problems facing the school which the Ofsted reports have since highlighted **[B]**.

Looking at the 2005 Ofsted report, the inspector highlights the deeper challenges which the school was faced with during this period.

> "*... some parents do not take their responsibilities seriously **[B]**, they do not encourage their children to attend regularly or complete their homework **[A]**" (Ofsted, 2005, p.7)*

Similar to School B, greater efforts were now required to improve the relations **[B]** between the school and parents. Indeed, the option to pursue more draconian measures was highlighted by Ofsted **[B]** when they explain,

> *"... the school does not shirk from supporting legal action to oblige parents to ensure that their child attends school" (Ofsted, 2005)*

At the same time, the procedures for monitoring student attendance were said to *"lack rigour, and do not allow the school to identify those who are missing from individual lessons... ".* The introduction of the electronic registration system **[D]** as part of the BSF refurbishment programme would hopefully address this problem.

In summary the report presents a picture of severe instability across the school, highlighting the major deficiencies as follows,

- *Exclusions and suspensions were considerably higher than the national average **[B]**.*
- *Attendance, punctuality and absence were a major concern **[B]**.*
- *Staff turnover was a big problem **[B]**.*

As a result, Ofsted continued to monitor the school, paying specific attention to the quality of teaching,

> "*The quality and pace of learning varied widely between the most effective lessons and those where learning lacks sufficient focus or purpose **[A]**... in too many lessons the specific objectives and outcomes of learning lacked clarity and teachers did not assess the progress that students had made or what they needed to do next **[A]**... passivity and low level disruption **[B]** was linked with dull or weaker teaching **[A]**." (Ofsted, 2006,p.2)*

One positive development which the inspector highlights identifies the "revised behaviour policy",

> "*The learning centre, along with the internal isolation unit, is operating effectively to support students with behavioural problems. Careful monitoring supports students' re-*

> *entry to school following exclusion. Closer contact with parents is helping build trust between families and the school..." (Ofsted, 2006, p.3)*

In 2007, the school appointed a new head teacher who was present throughout the BSF procurement process. Although he was subsequently replaced in 2009, the report suggests the primary goal of the head was to 1. Broaden the range of cultural experiences for students **[A/B]** and 2. Foster an ethos of working together **[B]** (Ofsted, 2007).

Put simply, teaching needed to improve and a closer relationship with parents and the local community needed to be established. In a follow up inspection (2008), the pace of changed was seen to be too slow, prompting Ofsted to replace the governing body and officially place the school under "special measures".

Immediate changes followed, included raising the bar for attainment by entering the most able students into GCSE exams a year early. More focused one-on-one support was provided for students on the borderline C/D grades. Furthermore, students with interests in vocational activities were encouraged to pursue the appropriate courses.

To further destabilise the school during this period, the BSF programme identified that at least one refurbishment **[D]** project should be included as part of the phase one programme. By circumstance, School D was identified as the most appropriate candidate based on the quality of the existing infrastructure (1930s red brick building with attractive clock tower). As a result, temporary classrooms were built over the duration of the 140 week project. Indeed, with the refurbishment project taking longer than any of the new build projects, the day to day reality in terms of managing student behaviour became increasingly apparent **[B3].**

> "*... a significant minority of students are persistently absent... [and] the number of fixed-term exclusions is increasing...* ***[B]****" (Ofsted, 2008, p.4)*

Furthermore, staff turnover was in crisis at this moment in time,

> "*There have been a number of substantial changes to the leadership structure and its personnel, as well as a 26% staff turnover within the college in the last two years* ***[B]****...*

> *The college's contribution to community cohesion is inadequate **[B]**. The college lacks a clear understanding of its duties and is not fully engaged with the local communities surrounding the college **[B]**. It has not analysed its contribution nor has it a strategy for contributing effectively in the future." (Ofsted, 2008, p.7).*

By the summer term of 2009, another (interim) head teacher had now been appointed. At the same time, a further 20 teachers left during the summer holiday bringing into question the long term viability of the school.

> "*... the members of the interim executive board remain unsure as to the long term future of the college and this is hampering their plans to provide a permanent sustainable strategic leadership..." (Ofsted, 2009)*

Fortunately, with the refurbishment crucially finishing in time for the new academic year (September 2009), stability in terms of the physical environment could finally be achieved.

A new system of student monitoring was also setup to identify individuals and groups who persistently played truant. For example, students were no longer allowed to leave the premises without permission. Previously, the lack of resources and facilities **[D]** limited the activities which students could enjoy. Now it was possible for hundreds of students to use the ICT resources simultaneously during break and lunch times.

The indoor and outdoor social spaces **[C]** were also much improved **[D]**, creating a stimulating environment which encouraged a greater sense of community **[B]**.

As a result, complaints made by local residents reduced substantially **[B]** now that students remained on site. Poor behaviour in class and throughout break times was also much reduced.

> "*The pupils' attitudes to college are more positive. Pupils report feeling safer and they understand that the college is making strong efforts to help them achieve more highly... Pupils are becoming increasingly involved in evaluating their own work and setting targets for improvement **[A]**." (Ofsted, 2010)*

During the 2010 summer holidays, a new head teacher was recruited. His job was to now bring a clear and stable leadership which had previously been lacking. In an interview with Leicester Mercury Newspaper (June 25th 2011) he also explains how the school was now responding to the pressures placed on families as result of the economic downturn **[E].**

> "*We realise there's a cost price to families where there might be more than one child who needs a uniform and trips to be paid for, that's why this fund aims to help. We're aware of our community's needs **[B]** and demands on household income are getting bigger **[E]**." (Head teacher, 2011)*.

At the same time, the new head explains how the new school uniform has helped changed the mindset of students,

> "*We've found the uniform has really made a difference. It's been one of the significant factors in making sure pupils have the right hat on for school... we want to make sure they arrive with the frame of mind that there are standards to adhere to and that includes behaviour **[B]**... We've found blazers and ties give them the right mindset and that's had a knock-on effect with their results **[A]**" (Head teacher, 2011)*.

Changing the culture of the school from the students' perspective was also an important part of the "transformation" process. In this regard, two students were quoted as saying,

> "*I think it [the uniform] looks smart and everyone wears the same, no one gets picked on for what they wear." "People who see us dress smartly and know we go to a good school" (Leicester Mercury, see appendix B)*

By chance, the researcher also identified a BBC documentary, "Poor Kids[24]", which aired in 2011, and highlighted the plight of three children living in the United Kingdom, one of whom went to School D. Eleven year old "Sam", (a boy), was the subject of bullying **[B]** because his father could not afford the uniform, Sam was forced to wear his older sister's hand-me-down school clothes. Consequently, the public reaction to this highly sensitive piece of journalism resulted in a

[24] http://www.bbc.co.uk/programmes/b011vnls

charitable fund **[E]** being setup for the poorest children. Furthermore, the emotive nature of such a documentary underlines the wholly laudable objectives which the BSF programme originally set out to address; namely to improve the quality of life of poor children in positions of disadvantage, not by charitable donations, but to empower them with the education, skills and confidence to make a better future for themselves!

By 2011, the school was released from special measures. Indeed, the improvements both in terms of attainment and culture were quite remarkable.

> "*Our mission statement 'learning transforms lives' illustrates our educational philosophy. We want all our students to value being good learners and to become independent and confident young people who have enquiring minds and the self-motivation to succeed" (School D Prospectus, 2011/2012)*

The website also acknowledges the contribution the new building has made **[D2]**,

> "*More recently, the college benefitted from £12 million **[E]** investment through the Building Schools for the Future programme. Under this programme School D retained its iconic 1930s red brick facade and clock tower, and combined a new glass facade and 21st century facilities to create an innovative and inspiring educational environment... the extent of the transformation is a surprise for everyone entering the college and for the first time... the spectacular new buildings **[D]** mirror the transformation of the college in terms of learning **[A]** and behaviour **[B]** achieved by staff and students over the past five years." (School D Website, 2012)*

The website also draws attention to the "Fischer Family Trust Index" which compares a range of demographic statistics alongside national examination data **[B/A]**,

> "*In 2010/2011, 50% more School D year 11 students achieved the benchmark of five GCSEs (at grade A* to C, including English and Maths) than the index suggested... whatever the realistic expectation of your child's GCSE performance, they are likely to achieve more at School D" (School D , 2012).*

Indeed, with the new facilities providing a learning experience that encouraged students to spend more time on site, disadvantages presented by their home life could now be minimised.

> "*Traditional homework has been replaced by extended learning projects* ***[A]****, which play an important role in helping your child achieve and make progress. Extended learning allows students to develop their – independent skills – thinking skills – research skills – problem solving skills – curiosity – creativity – Organization skills." (School D Website, 2012).*

Moreover, according to Gladwell (2008) who previously introduced the researcher to the 'Roseto Mystery', evidence[25] collected from the KIPP Academy in America highlights two factors which are instrumental in the development of academic success – Social Class **[B]** and the amount of time spent learning **[A]**.

Set up in the mid 90's in some of the poorest neighbourhoods of New York City, the demographic make-up of students attending the first KIPP school was described as follows,

> *"Roughly half of the students are African Americas; the rest are Hispanic. Three-quarters of the children come from single-parent homes. Ninety per cent qualify for free or reduced lunch" (p.251)*

Using the California Achievement Test (CAT), reading scores for the first five years of elementary school were recorded and broken down by socio-economic class – low, middle and high.

Class	**1st Grade**	**2nd Grade**	**3rd Grade**	**4th Grade**	**5th Grade**
Low	329	375	397	433	461
Middle	348	388	425	467	497
High	361	418	460	506	534

[25] Ross, Steven M., McDonald, Aaron J., Alberg, Marty and McSparrin-Gallagher, Brenda (2007) 'Achievement and Climate Outcomes for the Knowledge is Power Program in an Inner-City Middle School', Journal of Education for Students Placed at Risk (JESPAR), 12:2, 137 — 165

Points of interest from this data can be broken down as follows.

- Students start with similar scores in 1st grade.
- By 5th grade, 4 years later, the gap between rich and poor children more than doubles.

Possible explanations to explain this situation include,

- Disadvantaged children are not as intelligent (not true),
- Teaching may not be good enough.

However, by exploring the broader social circumstances which characterise the evolution of public funded education systems, Gladwell explains how the academic year has evolved as a result of many historical events and circumstances. It is well documented that children born in September for example have significant advantages both physically and educationally over children born in August. But to address the above phenomenon, he identifies the long summer holiday as the one period when the real disadvantage occurs.

To isolate what effect this holiday period may have on the three groups of students, CAT tests were administered twice per year, once in June, before the summer holidays and then again in September. They then looked exclusively at the performance increase from September to the following June i.e. excluding the summer holiday.

Class	**1st Grade**	**2nd Grade**	**3rd Grade**	**4th Grade**	**5th Grade**	**Total**
Low	55	46	30	33	25	189
Middle	69	43	34	41	27	214
High	60	39	34	28	23	184

Interestingly, the data confirms how all three socio-economic classes' progress at a similar rate. Even more apparent was the way reading tests conducted before and after the summer break demonstrate how working class children actually record a decline in their reading abilities following an 8 week break from their studies.

Class	**1st Summer**	**2nd Summer**	**3rd Summer**	**4th Summer**	**5th Summer**
Low	-3.67	-1.70	2.74	2.89	0.26
Middle	-3.11	4.18	3.68	2.34	7.09
High	15.38	9.22	14.57	13.38	52.49

In the light of this evidence, the founding director of Kipp, David Levin concluded that poor students need to spend more time learning as their family circumstances may inhibit the process of continual academic/intellectual development. The idea of developing “community” schools through programmes such as BSF may help to address the domestic inequities which arrest social mobility by encouraging students to attend school more regularly and for longer periods of time.

Interestingly, Gladwell is also sceptical about the predictable rhetoric which characterises the contemporary debate, concluding his analysis as follows,

> “*An enormous amount of time is spent talking about reducing class sizes, rewriting curricula, buying a shiny new laptop and increasing school funding... to build a better world we need to replace the patchwork of lucky breaks and arbitrary advantages that today determine success – the fortunate birth dates and happy accidents of history with a society that provides opportunity for all.” (p.268)*

It has therefore been necessary to reframe “Educational Transformation” not simply as a buzz word for increasing attainment through infrastructure renewal and the provision of ICT. Instead, the researcher’s “sustainable schools matrix” attempts to link together a whole range of disciplines and themes in order to create a new blueprint for 21st century education. Rebuilding the infrastructure is clearly an important part of this challenge; however, it is the cultural and behaviour attitude to education which needs to also be considered.

Indeed, as all four case-study schools will now demonstrate in the following sections, building social capital through establishing closer relations with parents and the wider community is essential to improving attainment and maximising the intellectual potential of all students who attend school in the United Kingdom.

7.2 School Statistics

Collecting the statistical data helps to anchor the research along a more conventional footing. As a result, the evidence presented below speaks for itself without the need for detailed statistical analysis.

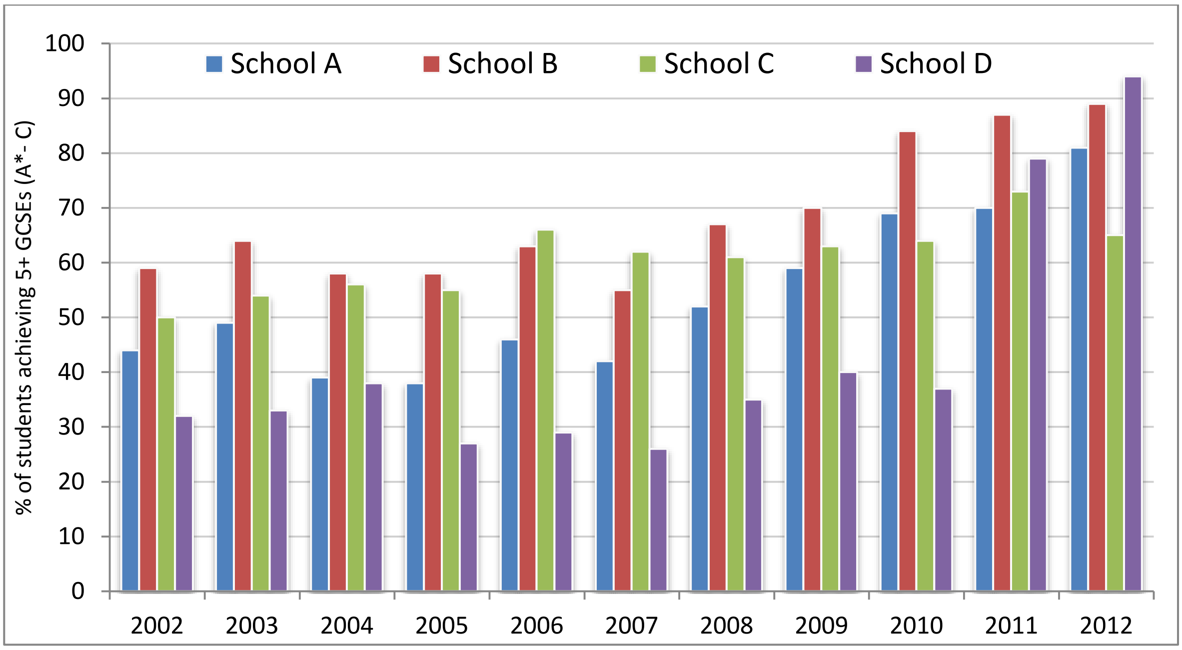


Figure 77. Examination Statistics

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
A	44	49	39	38	46	42	52	59	69	70	81
B	59	64	58	58	63	55	67	70	84	87	89
C	50	54	56	55	66	62	61	63	64	73	65
D	32	33	38	27	29	26	35	40	37	79	94

The upward trend across all four schools from 2010 onwards suggests the new buildings, in addition to the numerous managerial improvements, were having a positive impact. To what extent the new buildings were directly responsible for this outcome remains unclear, however, it is perhaps reasonable to suggest that the El-Enezi model helps to explain this change (see statement “2”, p.70).

Attitudes’ to learning and pupil behaviour can also be considered when constructing a social impression of a school. Figure 78 helps to illustrate the day to day changes in evidence.

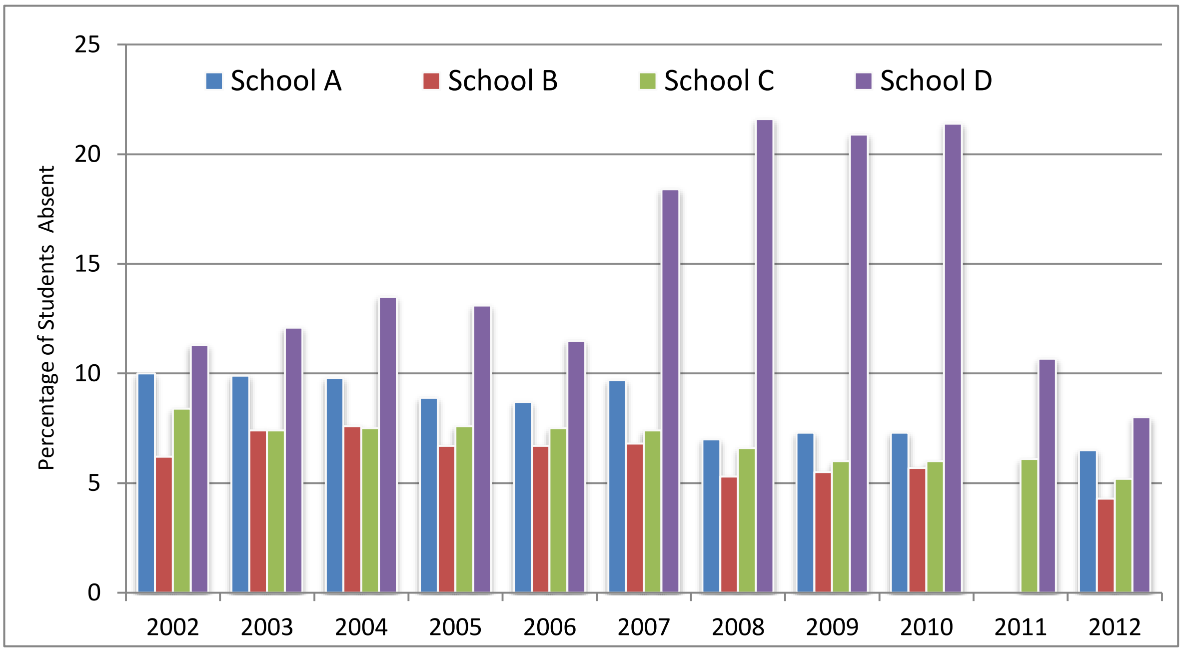


Figure 78. Student Absence Rates

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
A	10	9.9	9.8	8.9	8.7	9.7	7	7.3	7.3	-	6.5
B	6.2	7.4	7.6	6.7	6.7	6.8	5.3	5.5	5.7	-	4.3
C	8.4	7.4	7.5	7.6	7.5	7.4	6.6	6	6	6.14	5.2
D	11.3	12.1	13.5	13.1	11.5	18.4	21.6	20.9	21.4	10.67	8

In the old buildings, the average level of absenteeism was 9.5% from 2002 to 2009 **[B3]**. Once the four schools moved into their new buildings however, this figure dropped to 8.1% **[B3]**. Interestingly, it was the refurbishment project at School D which saw absenteeism significantly rise during the 140 week construction period (2007, 2008, and 2009). Indeed, whilst staff turnover was evidently a problem, the drop in attainment during this period was equally a concern. Future research may therefore wish to look at the additional disruption caused by refurbishment projects both in terms of attainment and student attendance.

In addition, gauging student attitudes' to learning before and after a new building has been occupied may reveal interesting results. Indeed, as the literature in this field has already confirmed, the condition of the physical environment is often more important to students than the actual curriculum itself. In this regard, it is interesting to observe how School D's attainment level dropped to only 26% in 2007 whilst absenteeism rose to over 20% during this same period. ..

Further consideration of the available statistical data reveals only marginal changes in the levels of educational and economic disadvantage across the four schools.

- SEN – Special Educational Needs
- FSM – Free School Meals

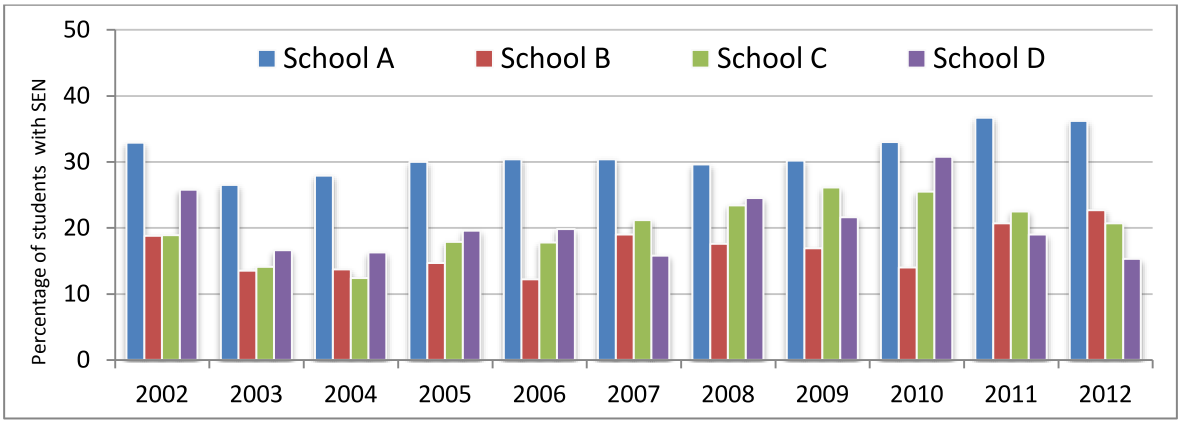


Figure 79. Special Educational Needs (SEN) Statistics

As the data reveals, School A has the highest percentage of students registered with SEN, further highlighting the important contribution this school has made. In general, all four schools were selected on the basis they could demonstrate various degrees of disadvantage. However, School B was generally regarded as the most "academic" school from phase one.

From an economic perspective, the number of children who qualify for FSM has marginally increased. School D in particular was an area of Leicester where many new migrants from Eastern Europe have recently settled. Set against the recent economic troubles following the banking crisis of 2008, the bar chart on the follow page illustrates the rising level of children who qualify for Free School Meals.

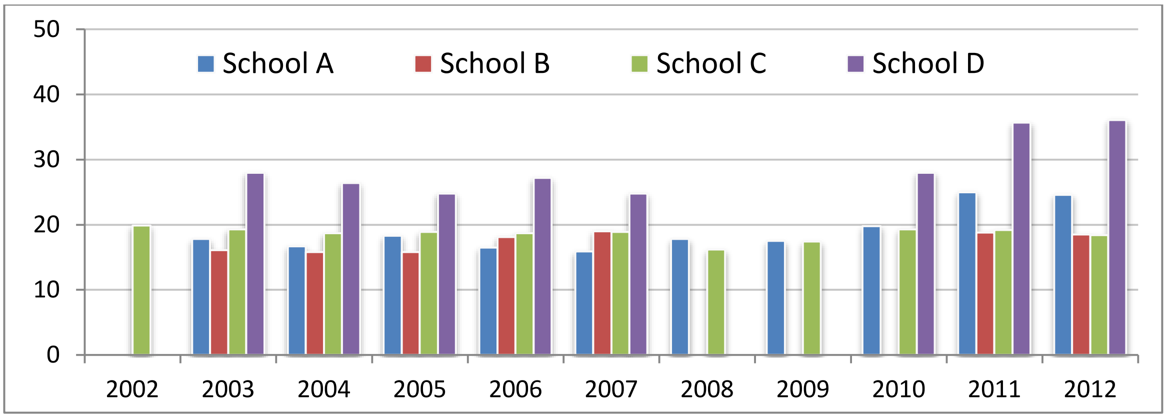


Figure 80. Free School Meals (FSM) Statistics

To what extent FSM is a causal or predictive variable which can be linked to levels of attainment or attendance is not clear. At School D for example, by 2012, a staggering 91% of students achieved 5 or more GCSEs at A to C grade, during which time FSM levels had actually risen.

In summary, the rising trend in attainment across all four schools demonstrates the positive educational "outcomes" which have been achieved over the space of 3 years **[A3]**. The new buildings can also be linked to improving behaviour as the attendance figures may suggest **[B3]**. Based on this evidence, it would seem that the El-Enezi (2004) (p.70) model provides a useful framework to explain the relationship between the physical and social environment within a school setting.

More generally, as Woolner *et al.,* (2007, p.47) conclude,

> *"... there are indications that environmental change can be part of a catalytic process of school development and improvement."*

Furthermore, with the statistical evidence nationwide highlighting a consistent link between attendance and attainment, further efforts to reduce absenteeism should be encouraged. In this regard, a building which is fit-for-purpose in the 21st century should not deter students from attending.

7.3 Parental Engagement (Ofsted Surveys)

Educational transformation it would seem has come to mean many things. Supportive parents can help to ensure their children attend school, arrive on time, behave appropriately and work hard. In this regard, educational success is very much about the school establishing stronger relations with parents **[B]**.

When the researcher was considering how he might be able to measure or evaluate this relationship, he identified a range of parental surveys which Ofsted had completed on two separate occasions (2002 & 2010). By studying this data and comparing the two surveys it was then possible to identify 8 common questions. For each question, a particular <u>theme</u> has been underlined below.

1. My child **likes** school (2002). My child **enjoys** school (2010) => <u>Happiness</u> **[B]**

2. My child is making **good** progress in school (2002). My child is making **enough** progress at this school (2010) => <u>Attainment</u> **[A]**

3. Behaviour in the school is **good** (2002). The school deals **effectively** with unacceptable behaviour (2010) => <u>Behaviour</u> **[B]**

4. The teaching is **good** (2002). The teaching is **good** at this school (2010) => <u>Teaching</u> **[A2]**

5. I am kept **well informed** about how my child is **getting on** (2002). The school **informs me** about my child's **progress** (2010) => <u>Communications</u> **[B2]**

6. The school **works closely** with parents (2002). The school **takes account of my** suggestions and concerns (2010) => <u>Parental Engagement</u> **[B2]**

7. The school is **well led and managed** (2002). The school is **led and managed effectively** (2010) => <u>Leadership & Management (L&M)</u> **[B]**

8. The school is **helping** my child become **mature and responsible** (2002). The school **makes sure** that my child is **well prepared for the future** (2010) => <u>Student Welfare</u> **[B]**

Source: Ofsted Questionnaires (2002, 2010)

Taking School A as a good example, the following page sets out the simple methodology which helps to identify any tangible differences between the two surveys.

Table 30. School A Parental Questionnaire 2002 Vs 2010 Comparison

Theme	Strongly Agree		Agree		Disagree		Strongly disagree	
	2002	2010	2002	2010	2002	2010	2002	2010
1: Happiness	33%	64%	55%	34%	8%	1%	2%	0%
2: Attainment	43%	57%	52%	42%	3%	2%	1%	0%
3: Behaviour	28%	42%	55%	54%	12%	4%	2%	0%
4: Teaching	34%	59%	57%	40%	4%	1%	1%	0%
5: Communications	34%	50%	46%	48%	15%	2%	4%	0%
6: Engagement	29%	41%	50	47%	14%	6%	3%	0%
7: L & M	34%	58%	54%	39%	3%	2%	1%	0%
8: Student Welfare	32%	50%	55%	45%	6%	2%	2%	0%
Average Score	29%	53%	53%	44%	10.5%	2.5%	2%	0%

Using the methodology highlighted below, tracking the degree to which attitudes' of parents have changed is possible.

If (Strongly Agree (2010)+ Agree (2010)) - (Strongly Agree(2002) + Agree (2002)) > zero
Parents are more supportive now in (2010) than before (2002)
However
If (Strongly Agree (2010)+ Agree (2010)) - (Strongly Agree(2000)+ Agree (2002)) < zero
Parents are less supportive now (2010) than before (2002)

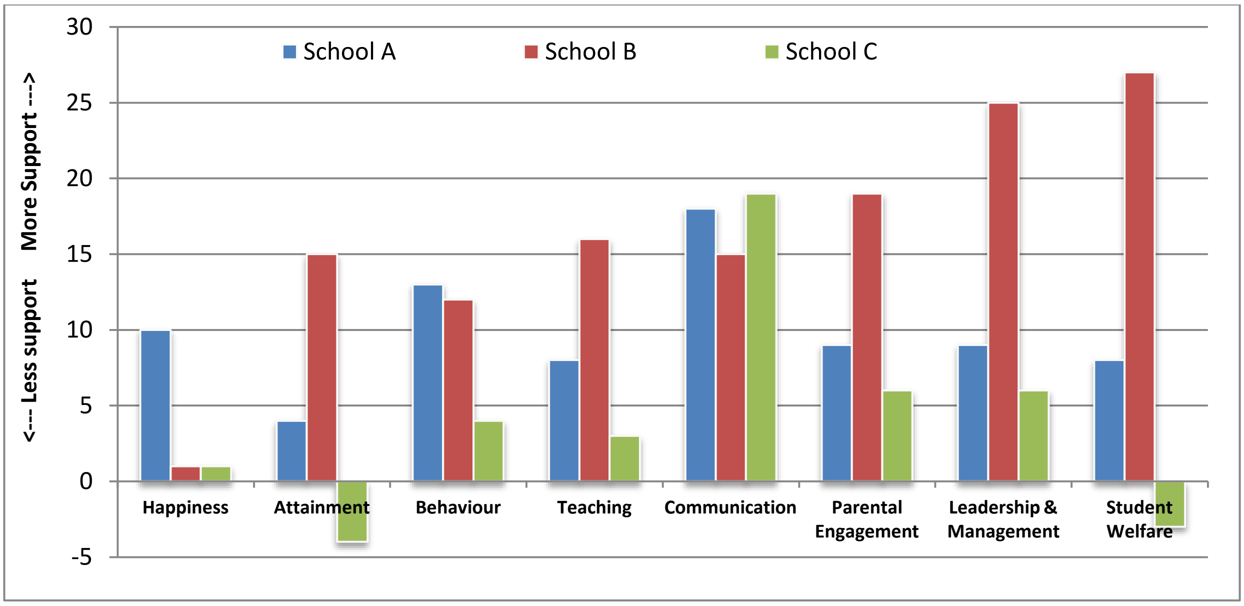


Figure 81. Parental Feedback

Unfortunately it was not possible to include School D in this comparative analysis as there was no survey data available in 2002 or 2010. The researcher can only speculate why this was so.

Interestingly, as it was Ofsted that already identified School B's failure to effectively engage and communicate with parents, these results demonstrate the resounding success of the new management team to improve this situation. In fact, figure 82 identifies how School B exhibited the greatest improvements across all 8 themes.

More generally, the marked improvement in "communications" across all three schools may also indicate that new technology **[D]** may have been a factor now that each school had a properly managed ICT infrastructure.

It has now been possible to rank each school on the basis of average scores;

1. School A = 9.875% improvement (parental perception)
2. School B = 16.25% improvement (parental perception)
3. School C = 4% improvement (parental perception)

From a "transformative" perspective more importantly, the general trend in the statistical data shows a consistent improvement. It also seems reasonable to assume that School D would probably have scored even better given the dramatic turnaround in the examination statistics.

Enhancing aspects of Sustainable Development through infrastructure renewal has many intangible benefits. Supportive parents for example is a essential ingredient in this respect. This form of trust and co-operation has often been termed "social" capital. Attempts to measure this particular phenomena are not so easy however. Fortunately, the availability of parental questionnaire data (Ofsted 2002-2010) helps to quantify this effect. However, future research and policy reforms will need to collect more data if new insights and solutions are to be found.

In the next section, feedback from staff in response to the new buildings has been considered.

7.4 Staff Satisfaction

Having identified a number of positive outcomes with respect to the improving levels of attainment and parental support, the next stage of the “educational transformation” analysis looks specifically at the experiences’ of staff working in the new buildings. To assist in this process the researcher selected the BUS methodology, a ‘tried and tested’ occupancy satisfaction questionnaire which includes a specialist database of more than 400 large commercial buildings (see dotted line on figure 83). This allows each case-study school to be examined more generally and objectively.

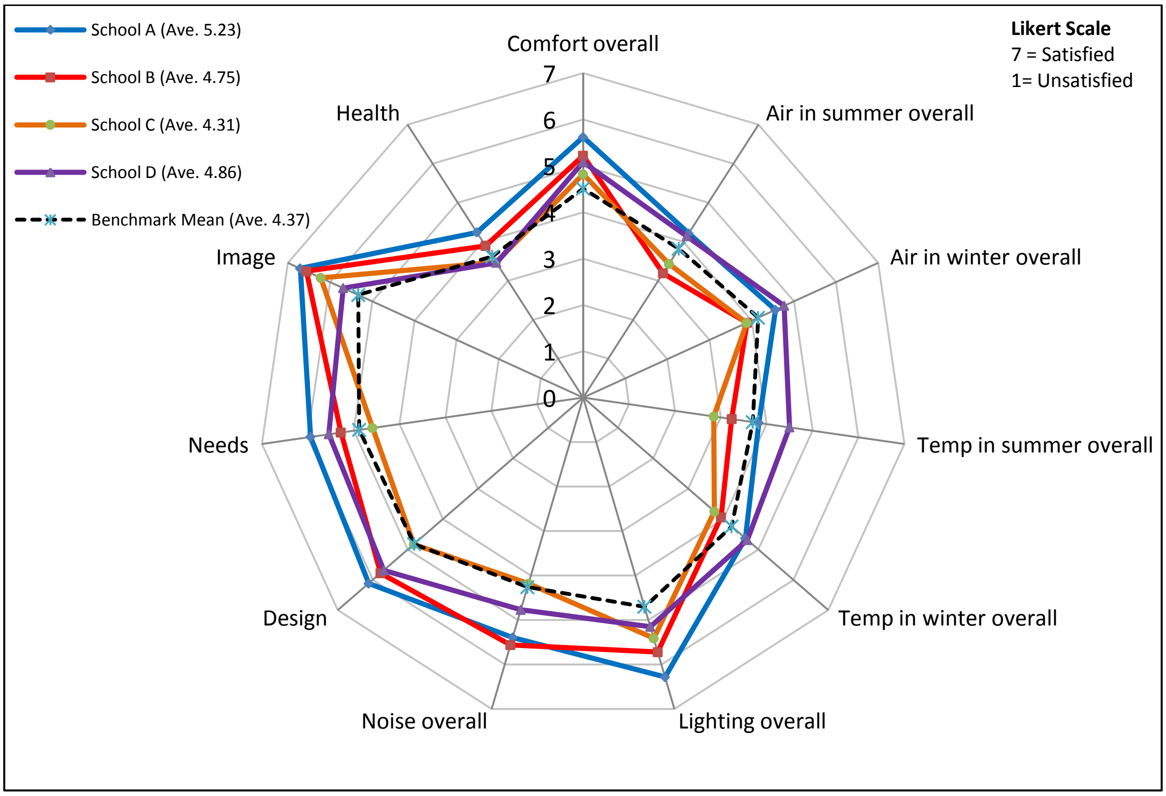


Figure 82. BUS Spider Diagram

As the spider diagram illustrates, School A posted the highest average score of 5.23 out of 7 on the likert satisfaction scale. By contrast, School C came last with 4.31, falling below the BUS average score of 4.37.

In the sections which follow, each school has been examined separately. Staff were also invited to elaborate on their experiences by including written feedback (see questionnaire in appendix).

A = Education; B = Community; C = Environment; D = Technology; E = Economics

7.4.1 School A: Staff Feedback

With School A having established itself as the more straightforward and conventional project out of the four phase one designs, documenting staff feedback about the practical day to day reality of the building helps to corroborate and/or confirm this school's overall effectiveness.

From a communications perspective, the researcher was contacted by the Head Teacher's secretary to arrange a meeting to discuss the proposed activities. In the absence of a dedicated business manager, the researcher was pleasantly surprised by the level of cooperation he received. After an initial meeting, an opportunity for the researcher to present his work to the staff was arranged for Monday 24th January 2011. The head teacher attended this presentation, and made sure that all staff were present. With hindsight, the researcher believes this was highly instrumental in helping to increase the number of questionnaires returned. Indeed, within a week, 34 questionnaires had been completed and returned. From a statistical perspective, the guidance documentation which accompanied the BUS methodology recommended a minimum sample size of 30.

NB. A red diamond indicates that the average (mean) score for a particular variable has fallen below the database "lower critical limit". This means the school for example has performed poorly in comparison to the 400 other buildings. Similarly, an amber circle indicates when a building's average score falls within the upper and lower limits of the database. If a green square is produced, the average score exceeds the "upper critical limit" reflecting a positive result.

One particular feature of the BUS questionnaire was the detailed 16 question section that relates to the environmental conditions in terms of temperature and air quality. On the following page, this section has been reproduced with the optimum denoted by a star ☆

In terms of the demographics of respondents, over 75% of the respondents were female and over the age of 30. Moreover, the 34 respondents included, the head teacher, receptionists, library manager, teachers from across the subject departments, teaching assistant, external careers advisor from "Connexion" etc. The sample was therefore representative of the wider population who work and use the building on a regular basis.

NB. The BUS methodology deliberately varies the location of the optimum (7, 4, 1), presumably to avoid respondents block ticking the questionnaire down a single column.

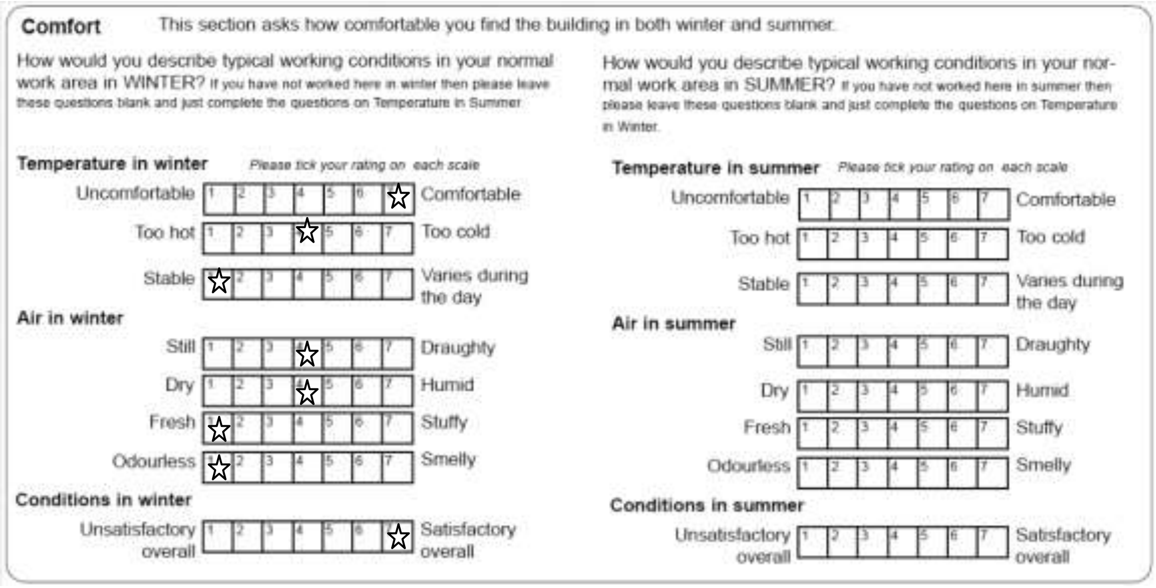


Figure 83. Questionnaire Layout

Using the BUS methodology to evaluate building comfort **[**an aspect of **C]**, the questionnaire includes a range of conditions which strengthen the validity of the analysis. Looking at figure 85 for example, staff at School A judged the indoor temperature to be 'too hot' in summer.

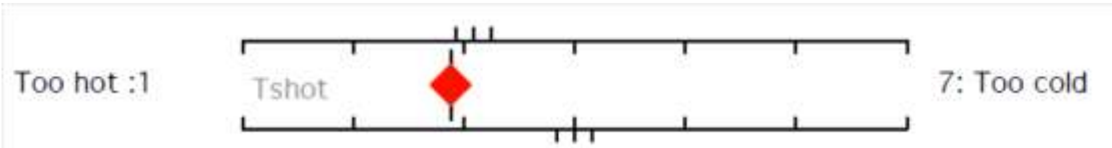


Figure 84. School A: Summer Temperature (Ave = 2.88, Benchmark = 3.09)

However, whilst temperature was clearly an issue for some staff, summer "comfort" scored more respectably (fig.86). Likewise, summer temperature was judged to be moderately stable (fig.86).

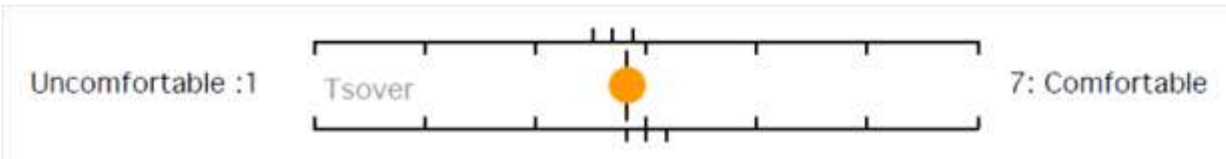


Figure 85. School A: Summer Comfort (Ave = 3.83, Benchmark = 3.7)

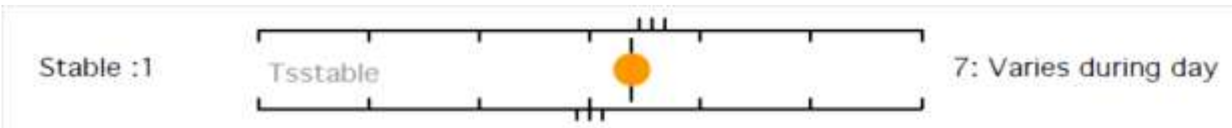


Figure 86. School A: Summer Temperature Stability (Ave = 4.38, Benchmark = 4.56)

Looking next at the set of results for winter, the graphics below highlight positive and negative results. The first thing to note was the way staff felt the building was too cold (fig.88). This was further exacerbated by the instability of temperature (fig.90). However, when asked to make a more general judgement about comfort in winter, the staff responded positively (fig.89).

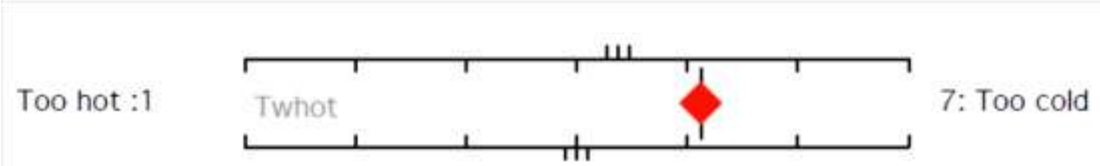


Figure 87. School A: Winter Temperature (Ave = 5.12, Benchmark = 4.38)

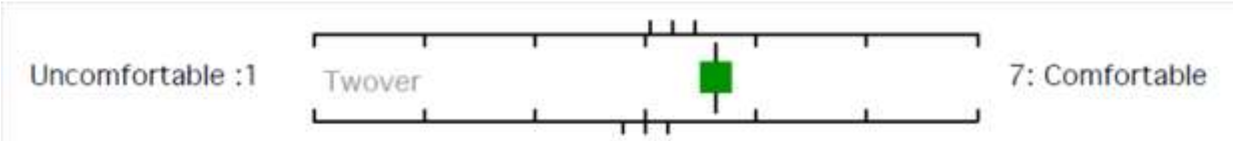


Figure 88. School A: Winter Comfort (Ave = 4.63, Benchmark = 4.24)

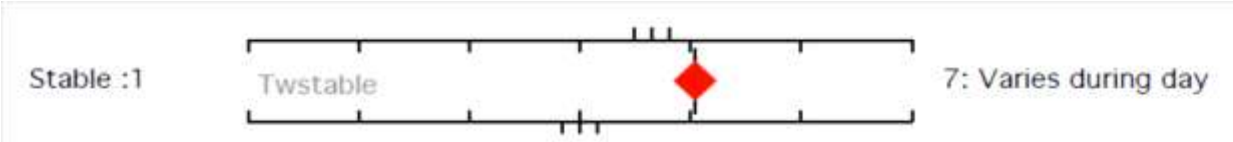


Figure 89. School A: Winter Temperature Stability (Ave = 5.04, Benchmark = 4.65)

In such circumstances, it is necessary to examine any additional comments made by staff which pertain to the issues of comfort and temperature across the seasons. As such, some staff felt obliged to make the following comments **[C]**,

> *"All the windows are very draughty", "Windows are not draught proof. Not always warm enough", "My only problem is in winter and the consistently low temperature", "Heating – windows draughty", "sometimes the room is cold", "Find it hard to stay late during winter as classroom becomes too cold", "Only room temperature, having to put coats on etc", "Have mentioned the draughty windows and the heating going off early in the day", "Nothing is done about window draughts and radiators",*

Evidently, faulty window seals and defective radiator thermostats appear to have been causing the problems which may explain the Likert scores in figures 88 and 90. There was also the suggestion that the gas central heating system switches off too early during winter **[D]**.

The next section requires staff to make judgements about air quality (too still – too draughty, too dry – too humid, too fresh – too stuffy, too odourless – too smelly).

Obviously with staff working in many different rooms, it is possible the variation in response scores may complicate and undermine the accuracy of the "average" likert scale data. It should also be remembered that the BUS survey was designed with offices in mind. On this basis, the researcher was mindful about the limitations of the questionnaire. Adapting the BUS methodology may wish to be considered as part of a national POE methodology for schools.

Taking a closer look at the four air quality conditions, the overlaps which exist may also help to confirm or identify the source of a problem. As winter had previously been causing problems, it came as no surprise when the wintertime, 'Still Vs Draughty' result yielded a negative response,

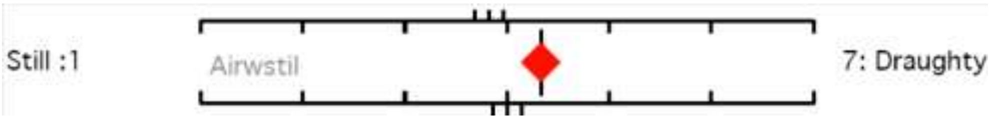


Figure 90. School A: Air in Winter: Still Vs Draughty (Ave = 4.33, Benchmark = 3.82)

Confusingly, when staff respond to the 'Still Vs Draughty' question in summer, the result indicates that air was 'too still'. Apart from cold air penetrating the building in winter, there may be a problem with the ventilation system which only becomes apparent in summer. Indeed, whilst the staff were mostly satisfied with conditions more generally, greater effort to commission and document this process would be advisable.

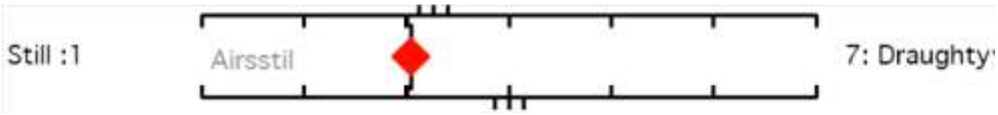


Figure 91. School A: Air in Summer: Still Vs Draughty (Ave = 3.04, Benchmark = 3.26)

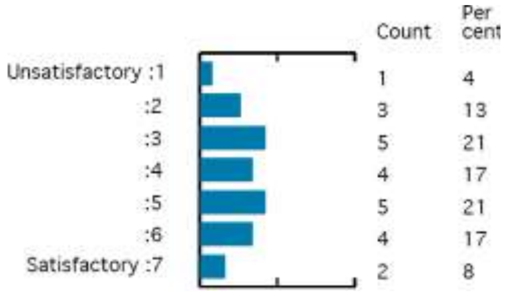
In terms of the remaining air quality conditions, the results have been summarized as follows,

Table 31. School A. BUS Air Quality

Condition	Winter	Summer
Dry (1) Vs Humid (7)	3.44	4.08
Fresh (1) Vs Stuffy (7)	4.04	4.76
Odourless Vs Smelly (7)	3.26	3.48

Indeed, since the amber and green indicates average and good scores (respectively), air quality was judged to be reasonably good throughout School A according to staff with the exception of draughtiness as evidenced by figure 91 (caused by faulty window seals).

Finally, when staff were asked to make a judgement about the conditions “overall”, taking into account seasonal variation, temperature and air quality, satisfaction scores in both summer and winter were predominantly average to good.



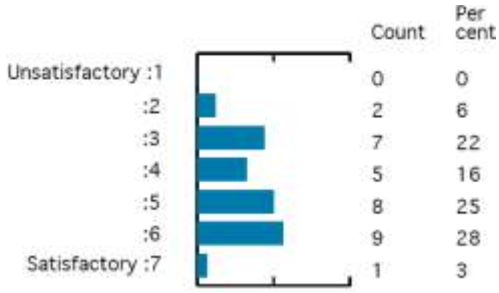
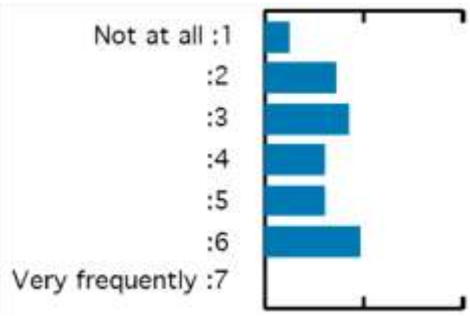


Figure 93. Sch. A Conditions “overall”: Summer (Ave = 4.21) **Figure 92. Sch. A Winter Overall (Ave = 4.56)**

Creating a productive environment requires a building to control the level of noise, especially in a school where hundreds of children are present. In total the BUS methodology includes 6 questions. However, as previously noted, the questionnaire was designed mainly for office use. This meant that four out of the six questions included “too little” as an option which did not seem to fit with the needs or concerns of a school teacher. The analysis has therefore chosen to look at only two results from the noise data – “unwanted interruptions” and “noise overall”. Both results were positive, yielding a “green square” based on average scores extracted from the database.



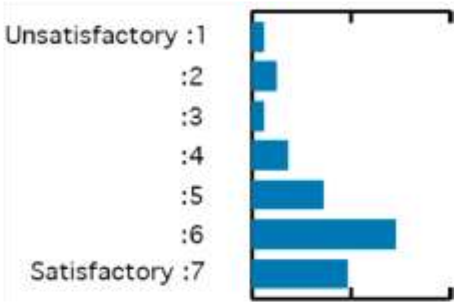


Figure 95. Sch. A Unwanted Interruptions (Ave = 3.88) **Figure 94. Sch. A Noise Overall (Ave = 5.39)**

The additional comments section also helps to identify specific problems which staff encounter on a regular basis. The office was the location where the most “disruption” appeared to occur,

> “*Classroom walls are very thin, students bang on the walls in the corridors and it echoes”, “Corridors get noisy when class change over. Lunch times and breaks can be noisy when*

on the phone to people", "Our office is in large hub area so at break the noise is far too loud and raucous", "Not enough work area in office. Office too small. If someone has to have a conversation whole office is interrupted. Too much noise in the library during breaks"

Indeed, as a result of the concrete floors throughout the building, noise reverberation was a cause for concern. Locating the offices away from the main circulation areas would be one solution. Alternatively, some form of carpeting or better sound insulation in walls and doors may help. Curiously, staff members noted how the toilet hand drier would often signal a student was not in class as the toilets were open plan and located near to the offices.

Lighting was another variable which the BUS methodology divides into a number of questions. Again the 'too little' – 'too much' scale was used in two out of the five questions. The data confirms that staff on the whole felt there was too much artificial light (4.5, red diamond), but adequote natural light (3.91, green square). However, when staff were asked to make an overall judgement, their response scores were notably positive (fig.98 – below left).

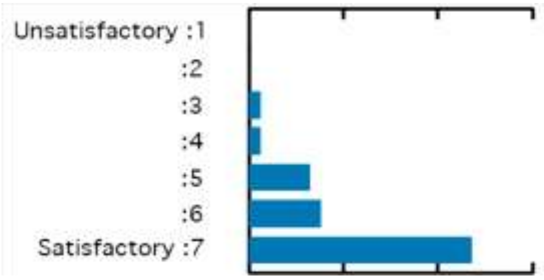


Figure 97. Sch. A Lighting Overall (Ave = 6.28, green)

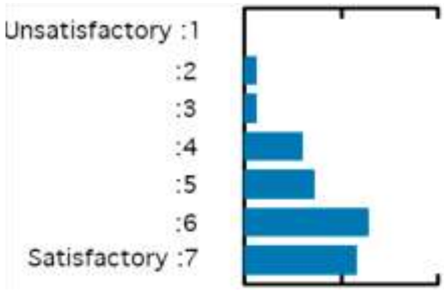


Figure 96. Sch. A Comfort Overall (5.62, green)

Indeed, when the questionnaire asked staff, '*All things considered, how do you rate the overall comfort of the building environment?'* taking into account seasonal shifts in temperature, air quality, noise and finally lighting, staff were again mostly positive about their experiences as figure 97 (above right) illustrates.

The questionnaire then required staff to make a judgement about how the new building may have affected their productivity using an extended 10-point likert scale (see below). The questionnaire also prompted staff to consider how the new building compares to their past experiences 'of using buildings in general', namely the old building.

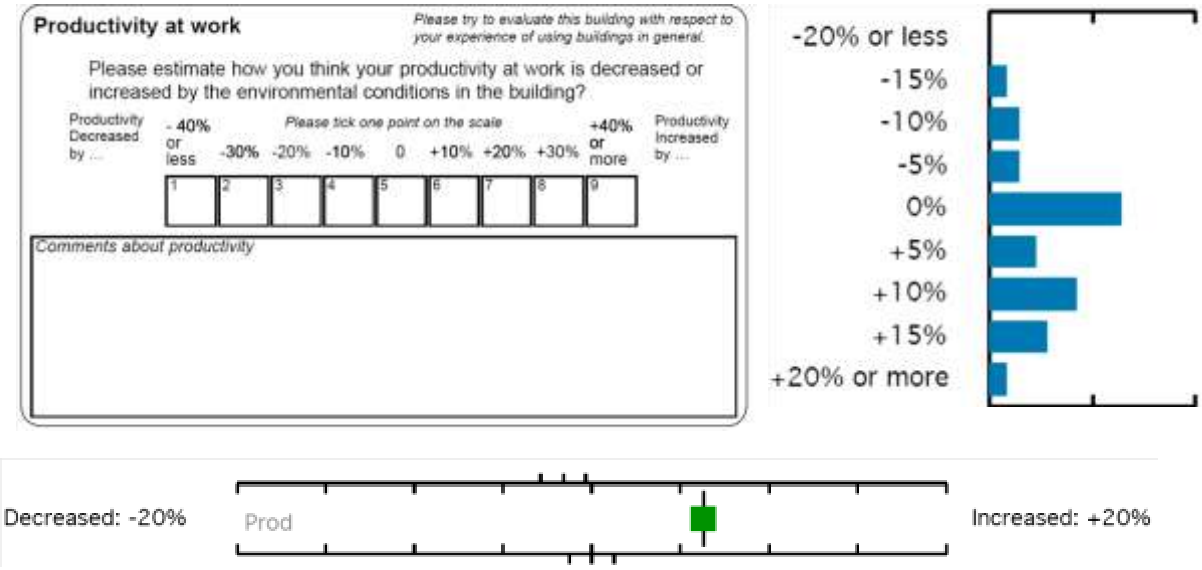


Figure 98. School A: Productivity (BL average = 7.86; Benchmark Ave = - 2.03)

As the two graphics above clearly demonstrate, the staff felt that productivity had improved in the new building by +7.86% **[A3]**. In contrast, the benchmark mean of -2.03% confirms how buildings more generally are failing to provide an effective environment. All things considered, this feedback helps to confirm the important contribution the new building is making according to the people who work there every day.

7.4.2 School B: Staff Feedback

Similar to the experience at School C, the researcher was unable to present his work to staff and had limited opportunity to establish a working relationship with the business manager **[B]**. In total, only 18 questionnaires were completed, limiting the ability to generalise the results.

Table 32. School B: Winter Temperature and Air Quality

Temperature: Uncomfortable – Comfortable	**Orange Circle – Ok, Slightly uncomfortable (3.94)**
Temperature: Hot – Cold (4)	Red Diamond – Too cold (4.71)
Temperature: Stable – Varies (1)	Red Diamond – Varies (5.2)
Air: Still – Draughty (4)	Green Square – Ok (4.07)
Air: Dry – Humid (4)	Orange Circle – Too dry (3.38)
Air: Fresh – Stuffy (1)	Red Diamond – Too stuffy (4.81)
Air: Odourless – Smelly (1)	Orange Circle – Ok (3.87)
Conditions Overall: Unsatisfactory – Satisfactory	**Orange Circle – Ok (3.89)**

Table 33. School C: Summer Temperature and Air Quality

Temperature: Uncomfortable – Comfortable	**Red Diamond – Uncomfortable (3.24)**
Temperature: Hot – Cold (4)	Red Diamond – Too hot (2.31)
Temperature: Stable – Varies (1)	Red Diamond – Varies (4.8)
Air: Still – Draughty (4)	Red Diamond – Too Still (2.56)
Air: Dry – Humid (4)	Red Diamond – Too Dry (3.56)
Air: Fresh – Stuffy (4)	Red Diamond – Too Stuffy (5.5)
Air: Odourless – Smelly (1)	Orange Circle – Ok (3.81)
Conditions Overall: Unsatisfactory – Satisfactory	**Red Diamond – Unsatisfactory (3.19)**

As tables 32 and 33 confirm, staff were generally dissatisfied with the internal conditions as far as temperature and air quality were concerned.

It was also noted how School C and B had exactly the same score for the Still vs Draughty (4.07 - Green). On reflection, a larger sample size becomes increasingly important when the optimum resides at 4 in the middle of the likert scale. A redesigned BUS survey may wish to consider modifying the likert scale system for buildings with fewer adult occupants, e.g. primary schools.

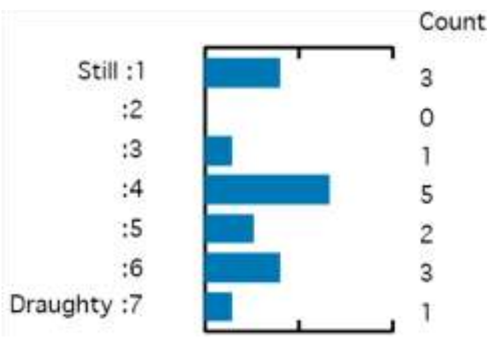


Figure 99. Sch B: Air: Still – Draughty (4.07)

Looking at the conditions which relate to the ventilation system, it was evident from the two bar charts below that air quality was a problem in summer and winter. Indeed, the FM team, unfamiliar with the BMS-963 software system, manually experimented with the classroom “smoke vents” to increase the air flow **[D]**. By chance, this ad-hoc arrangement worked in the short term.

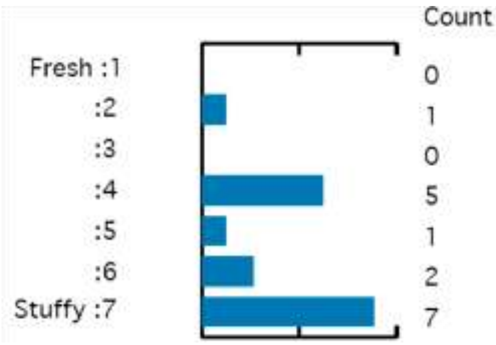


Figure 100. Sch. B: Summer Air Quality (stuffy)

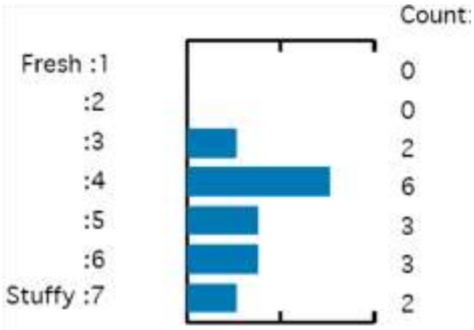


Figure 101. Sch. B: Winter Air Quality (stuffy)

Unfortunately, the problems with ventilation were not isolated to the classrooms. Staff working in the library, offices and staff rooms were also reporting problems associated with the HVAC system.

Noise was also a problem until such time as the contractor updated the internal environment by installing new ceiling tiles **[D]**. Previously one staff member described the situation as “unbearable”.

Table 34. School B: Noise

Noise Overall: Unsatisfactory – Satisfactory (7)	Green Square – Satisfactory (5.56)
Noise from colleagues: Too little – Too much (4)	Orange Circle – OK (4.29)
Noise from other people: Too little – Too much (4)	Orange Circle – Ok (4.33)
Other noise from inside: Too little – Too much (4)	Red Diamond – Too little (3.89)
Noise from outside: Too little – Too much (4)	Green Square – OK (4)
Unwanted interruptions: Not at all – Very frequently (1)	Red Square – frequent (4.24)

As table 34 helps to confirm, whilst some aspects of the questionnaire were a little confusing in relation to the idea that “too little” noise is equally problematic as “too much” noise, these results tend to suggest the building was reasonably effective in terms of minimising noise disruption as the “overall” condition scored 5.56 out of 7. It was also observed during the walk-through inspection how the internal environment was dominated by large open plan spaces with concrete floors. This design feature **[D]** possibly helps to explain why "other noise from inside" yielded a negative score. Obviously the downside with carpeting the indoor circulation areas relate to aesthetics, cleaning and replacement costs.

As for lighting performance, the feedback from staff indicate a mixture of opinions. Again however, the questionnaire places the optimum at "4" in 3 out of the 5 conditions, making the results more difficult to interpret without reference to the bar-chart distribution graphics. Lighting "overall" is therefore seen to provide a more reliable assessment (5.72 out of 7). Again however, if the questionnaire focused on presenting questions in such a way that the optimum resides at either 7 or 1, the likert data from smaller samples may become more reliable.

Table 35. School B: Lighting

Lighting Overall: Unsatisfactory – Satisfactory (7)	Green Square – Satisfactory (5.72)
Natural light: Too little – Too much (4)	Orange circle – Ok (3.78)
Glare from sun and sky: None – Too much (4)	Red Diamond – Too much (4.39)
Artificial Light: Too little – Too much (4)	Red Diamond – Too much (4.61)
Glare from lights: None – Too much (1)	Orange Circle – Ok (3.83)

In terms of "perceived" productivity, the average score of -1.24% indicates the building was actually inhibiting the capacity for staff to carry out their duties. Under the circumstances, with a budget of £21.5 million, this result supports the position held by the author of the BUS Survey, Adrian Leaman, when he explains how the mindset of design teams too often focus on the delivery of a notional "optimum", rather than "satisfying" the needs of the building user, namely the teacher, the administrator, the technician etc. Pertinent comments in this regard were noted,

> "*I feel tired and headachy if I have to spend time in my office", "I do find the building cold in the winter despite wearing extra layers...", "In the summer it can get up to 36°C in my room. I've had students asleep...", "The general lack of storage, display space and the awkwardness of the room overall cause problems that impede work", "The room can be stuffy in the summer, especially in the afternoon with the sun on the windows and little air circulation.", "If it's windy the blind moves a lot"*

Buildings such as School A could be described as “fit for purpose” as they “satisfy” the basic needs of the staff. Indeed, without the budgetary limitations placed on this project, it is conceivable that a more advanced solution would yield less positive results, both in terms of comfort **[B]** and energy efficiency **[C/D]**. More money does not therefore equate to better buildings as some practitioners have previously argued, namely the FM staff. Finding a balance between a tried and tested layout design, supported by more advanced low-carbon technologies would be a sensible strategy to adopt in the majority of projects. However, the researcher also accepts that ‘some’ projects may need more money if the design solution is more innovative.

Indeed, experimentation as demonstrated by the preference towards “open plan” is a common debate which has yet to be resolved among architects and teaching professionals alike. Furthermore, as the following comments confirm, various elements of the design were criticised by staff,

> “*I think there is a lot of wasted space”, “The car park is too far from the main school – difficult in bad weather”, “Too many sinks, oddly positioned power points, obtuse layout.” “Extremely inefficient use of space”, “open areas not used effectively”, “whiteboards too high on the wall. Display too high on wall, toilets too far from meeting rooms, particularly for visitors”*

At the same time, the likert data would suggest the staff were mostly positive about the design.

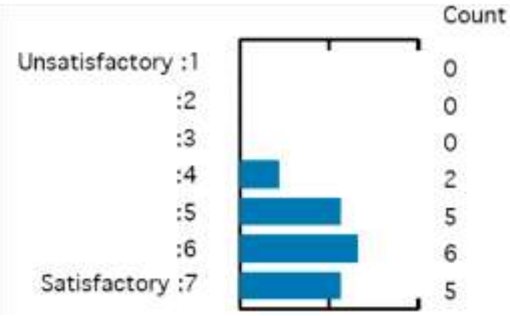


Figure 103. Sch B: Design

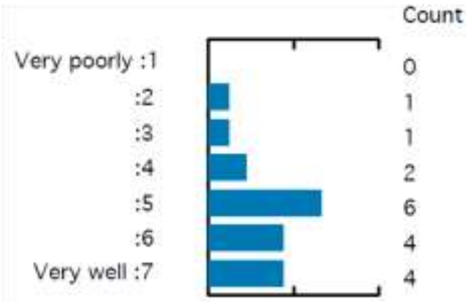


Figure 102. Sch B: Needs

However, based on the evidence presented across the three new build projects, School B and C, with their larger budgets, were not obviously more comfortable, desirable or efficient (than School A).

7.4.3 School C: Staff Feedback

As a direct contrast to School A, one should recall from the spider diagram that School C recorded the lowest average score (4.31) across the 11 key variables. It has therefore been helpful to investigate more thoroughly the staff feedback, especially the qualitative data, and consider how these problems can be fixed or avoided in the future.

Incidentally, School C was actually the subject of an ongoing post-occupancy evaluation, conducted by the Education Consultant and former head teacher at School D, when the PhD research student first began his study in October 2009. Unfortunately this work was discontinued when the Education Consultant successfully secured a new teaching position in early 2010. Fortunately, the researcher was able to spend some time with this individual, discussing his experiences both at School C and D. During 2009, he developed his own bespoke questionnaire designed specifically with teaching staff in mind.

His approach was to compare the response scores of teachers before and after the new building was occupied. In March 2009 when still in the old building, teachers completed his survey. This was again repeated in September 2009. However, the researcher became aware of the practical limitations his methodology was presented with. Firstly, not all the schools were surveyed before they were demolished. Secondly, it was too early for teachers to make a proper judgement about the effectiveness of the new building. And thirdly, the researcher was not convinced the questionnaire was sufficiently rigorous to address the multitude of issues presented by a building. Based on these three issues, the researcher was keen to employ an established methodology that would carry greater credibility in determining the quality of the four buildings.

In total 23 variables were assessed using this bespoke methodology. The rating system was organised as follows, with a summary of his findings presented on the following page.

1 = Unacceptable,
2 = Poor,
3 = Satisfactory,
4 = Good,
5 = Excellent.

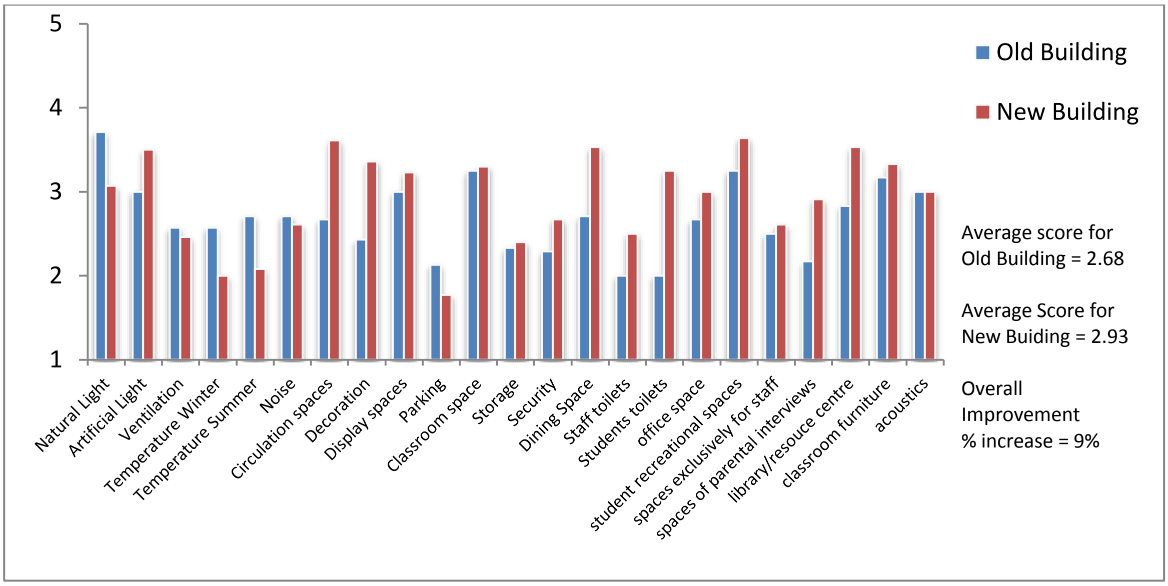


Figure 104. School C: LCC POE Data (2009)

Apart from the 9% improvement across all 23 variables which is positive, the provision of “natural light” suggests the old building outperformed the new building. This anomaly cannot be explained, and the researcher suspects the opposite may in fact be true. Indeed, the new building placed natural light at the heart of the design philosophy.

Looking next at the open-ended written feedback which was included on his questionnaire, it is clear how staff were upset by a number of issues which link back to the original consultation phase, as well as the operational management of the building post-occupancy.

> “*The lack of any ability to personalise individual classrooms leads to an extremely sterile environment. I am finding myself unable to display genuinely educational resources due to excessively rigid restrictions imposed by the FM providers”* ***[A]***

> *“Despite the intense ‘consultation’ it seems rather too predictable that a block of three departments end up with essentially identical rooms that staff cannot make basic adjustments (moving display boards) to suit their individual needs”* ***[B/D]***

> *“Support staff have not been included in any aspect of this new building”* ***[B/D]***

> *“... more input in planning and organisation of rooms and equipment would have saved a great deal of anguish.”* ***[B/D]***

"Hopefully a less 'one size fits all' approach will evolve"

"Office space and office equipment non-existent. Storage space very poor. The office appears as an afterthought and totally unsuitable. Staff areas have vanished. Even when you use the staff room it is like being on Ryan Air." ***[D/B]***

More positive feedback was also noted,

"*The whole environment is wonderful. Being able to see and feel the outdoors shining through to the corridors and classrooms really opens the space as well as the mind"* ***[D/B]***

"It's lovely for the students to learn and grow up here. It's now calm and you can almost feel the students' contentment. I enjoy every lesson I teach, the possibilities now seem endless." ***[B/A]***

Looking next at the results from the BUS questionnaire, comparisons between the two data sets may help to confirm whether the problems identified in this survey continued to persist.

The first thing to note was the disappointing return rate of 18 completed questionnaires at School C. The BUS methodology advises that an assessor handout and collect the questionnaires on the same day to maximise the return rate. The researcher suggested an inset day may be a good time for busy staff to complete the form. In the end, the researcher delivered the questionnaires by hand to the business manager who then put them in staff pigeon holes. On reflection, if the researcher had been able to present his work to staff like he did at School A more completed questionnaires may have been returned.

On the following page, a summary table helps to condense all the main results, avoiding the need to repeat the more extensive analysis presented for School A.

NB. Red => Bad result; Amber => Average result; Green => Good result

Table 36. School C: Winter Temperature and Air Quality

Temperature: Uncomfortable – Comfortable	**Red Diamond – Uncomfortable (3.75)**
Temperature: Hot – Cold (4)	Red Diamond – too hot (3.85)
Temperature: Stable – Varies (1)	Orange Circle – varies (4.71)
Air: Still – Draughty (4)	Green Square – OK (4.07)
Air: Dry – Humid (4)	Red Diamond – too dry (2.47)
Air: Fresh – Stuffy (1)	Red Diamond – Too stuffy (4.57)
Air: Odourless – Smelly (1)	Orange Circle – Ok (3.46)
Conditions Overall: Unsatisfactory – Satisfactory	**Orange Circle – Ok (3.88)**

Table 37. School C: Summer Temperature and Air Quality

Temperature: Uncomfortable – Comfortable (7)	Red Diamond – Uncomfortable (2.85)
Temperature: Hot – Cold (4)	Red Diamond – Too hot (2.46)
Temperature: Stable – Varies (1)	Orange Circle – varies (4.64)
Air: Still – Draughty (1)	Orange Circle – Still (3.33)
Air: Dry – Humid (4)	Red Diamond – Too dry (3.33)
Air: Fresh – Stuffy (4)	Orange Circle – Too Stuffy (4.62)
Air: Odourless – Smelly (1)	Orange Circle – Ok (3.73)
Conditions Overall: Unsatisfactory – Satisfactory	**Red Square – unsatisfactory (3.43)**

As can be seen from the 16 conditions, only a single green score was produced, which on closer examination emerges as a result of an averaging calculation when the optimum resides at 4, in the middle of the likert scale, hence the need to examine the bar chart distribution graphic to the right (especially when the sample size is limited).

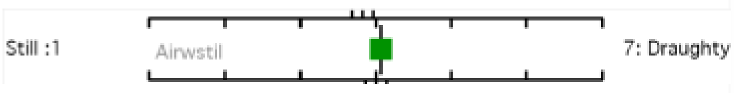
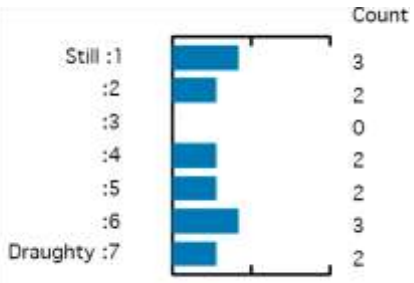


Figure 105. School C: Winter Air: Still – Draughty



When the acoustic performance of the building was investigated, the qualitative feedback highlights the HVAC system as one source of "noise disruption". Given the problems with the heating system more generally, it was not clear whether this noise was indicative of the system not working properly.

> "*Constant noise from air conditioning (extremely noisy)", "It is like being on a long haul plane. It stops at around 3:40pm when this system shuts down", "The air conditioning comes on at 7:30am goes off at approximately 4pm. It is like being on a long haul flight"*

This discovery has thus prompted the researcher to consider the underlying causes behind this problem. Was the HVAC system poorly commissioning, or was the building's design flawed more generally? As far as the noise problems were concerned, inadequate commissioning seems more likely. The overheating problems however may suggest the building's general design was more to blame.

The new building was designed so that the BMS system would regulate air flow and temperature, but we now know from the re-commissioning report that the control system was not properly configured. Furthermore, with the BMS system designed to control the amount windows open or close, staff were also critical about the way the building limited their capacity to control the environment.

Indeed, when asked the following question, '*All things considered, how do you rate the building design overall',* staff were only moderately satisfied (4.83/7) by their building when compared with School A (6.12/7) for example.

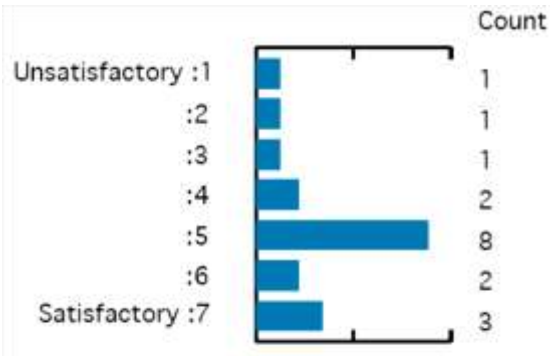


Figure 106. School C: Building Design (JM = 4.83 Vs BL = 6.12)

Looking for more evidence to explain why the design was failing to satisfy the needs and expectations of staff, the open plan design **[D]** was not seen to be making a tangible difference to the school's productivity. Furthermore, the energy required to heat and light these spaces also demonstrates how the interpretation of "educational transformation" can easily be redefined.

As it was, the school's BSF team made the decision to create an aesthetic which would raise aspirations. However, it would seem that energy efficiency may have been sacrificed in an effort to satisfy the preferences of the Head Teacher. Indeed, by looking at the frequency of complaints regarding storage, a more functional and utilitarian design would be preferable. Furthermore, as Preiser (2005) explains, aesthetics exist only on level 3 (see p. 37) in his BPE hierarchy.

> "*Lack of storage", "Lack of storage space for work and materials. Staff rooms needs to be larger", "Staff room small, difficult at lunch times to find space in there", Need more storage", Not enough science labs. Prep room too small", "Lack of suitable storage for equipment, chemicals, books etc", "Limited space in technology things have to be stacked high"*

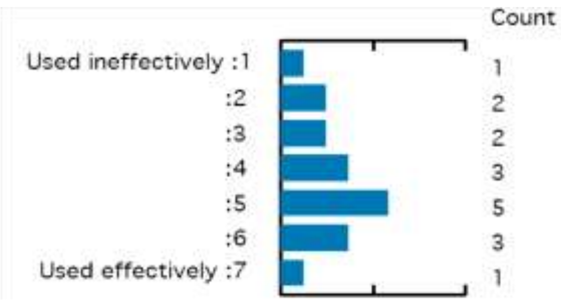


Figure 107. Sch. C: Space Orange Circle (4.29)

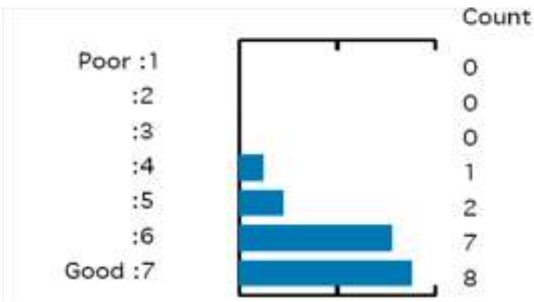


Figure 108. Sch. C: Green Square (6.22)

To conclude, School C's BUS performance tends to suggest both the design and the commissioning were responsible for the various frustrations and discomforts outlined by staff. It could also be suggested that aesthetics, namely the client's desire for natural light and open plan spaces had a negative impact on energy efficiency and overheating. Furthermore, whilst the biomass technology was seen to address the environmental requirement, it was not a visible technology that promotes a more sustainable way of life. As a result, opportunities to project sustainable development through low-carbon architecture were lost. Moreover, the building provided little opportunity to engage students in the science of renewables technologies. Given the £20m budget, a small array of PV panels or indeed a small wind turbine would have addressed this final concern.

7.4.4 School D: Staff Feedback

The researcher wrote directly to the four head teachers in December 2010, introducing himself and summarising his work to date. During this period the researcher became aware of the problems facing School D through conversations with the former head teacher who was working for the council as the in-house (POE) education consultant.

When the researcher first visited the school on the 8th July 2010 as part of the walk-through inspection, the school did not have a business manager in post. Unlike School A however, the researcher found it more difficult to establish a relationship with the school. Indeed, it was several months before the head teacher's secretary replied to the various letters and emails which the researcher had sent.

When finally the questionnaires were delivered to the secretary and placed in staff pigeon holes (along with a covering letter outlining the research objectives), only 6 questionnaires were completed and returned. To increase the sample size, the researcher set up the online version of the questionnaire as a backup plan. An email was then sent to staff (see appendix) which produced a further 7 completed questionnaires. The BUS guidance document advises that questionnaires be handed out and collected on the same day. The researcher did propose an inset day would be a good time for staff to complete the questionnaire as it took only 10 minutes to complete but unfortunately this could not be arranged.

With a total sample size of 13, the likert scale data on its own could not be relied upon. Only when there was a clear (one-sided) pattern in the distribution of response scores was it possible to draw any provisional conclusions. As a result, the analysis presented in this section relies mostly on the written feedback by staff.

As discussed already, School D was experiencing high internal temperatures due to sunlight radiation and internal gains from the lighting, ICT equipment and occupants. It was also apparent how some rooms in the building were not 'fit-for-purpose' as previously discussed, namely a small office, 2 science labs, the reprographics room and finally a woodwork technology room. As a result, the following comments have been noted,

> "*Extremes of temperature – harder to concentrate", "The room we occupied... was too small for three people, no natural light and nowhere to store equipment." "Quite often had a headache from having no natural light and felt depressed", "Lack of windows in some offices, lack of meeting space no nature light in rooms", "Office space over crowded, not enough computers in office. No windows/air flow in office. No storage for resources"*

Without interviewing staff, it was also not clear how much involvement staff had during the design phase. Interestingly however, the following comment may suggest not enough (involvement),

> "*Designed by someone who has never worked in a school... not enough storage for student work... not enough space... lack of telephone... air quality too dry and dusty... ventilation is poor... lighting levels are too dim at some machines..."*

FM staff also raised concerns about inconsistencies relating to the "as fitted" drawings and the final design. This may well explain why specific rooms were failing to provide a comfortable and healthy environment. Under the circumstances, given the educational and social challenges facing the school at this time, as well as the complexity of refurbishing an old building, the fact that the contractor was able to complete this project on time and on budget should be seen as a major success.

It has also been noted how some classrooms which face due south as part of the original building were now experiencing glare problems when using ICT equipment. These rooms were also susceptible to overheating. However, by opening the windows, the breeze outside would disturb the blinds causing visibility problems when using the overhead projector. This scenario is now common place in schools now that ICT has become a common tool in classrooms. Under the circumstances, the researcher feels that until such time as a window design has been developed that houses a blind within the double glazed window panels **[D]**, comfort and visibility problems will continue to persist.

> "*Sunlight causes hindrance to computer screen. If the blinds are shut its ok, but if windows are open, then blinds move and screen is not usable", "Blinds have to be closed at all times in some classrooms to enable the interactive whiteboard"*

Looking now at the likert scale data, the question, '*How do you rate the image that the building as a whole presents to visitors?'* produced a distinctly positive response.

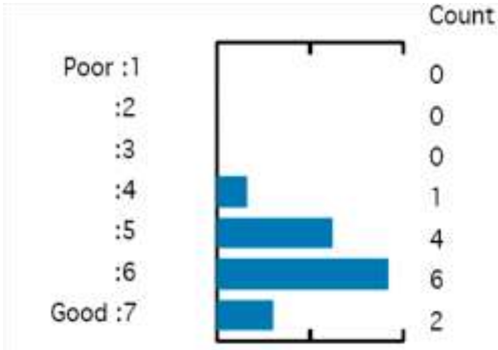


Figure 109. School D. Image to Visitors (5.69)

In terms of general comfort, those staff who did complete the questionnaire were mostly satisfied by the conditions overall as figure 111 below confirms.

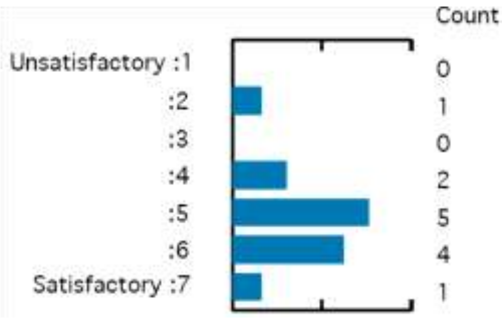


Figure 111. School D: Comfort (5.08)

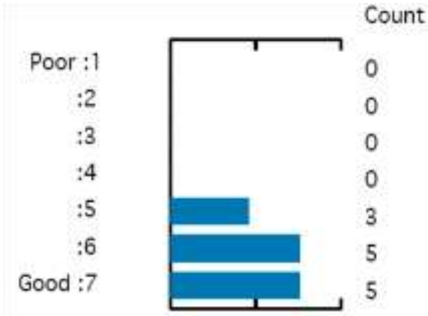


Figure 110. School D: Safety (6.15)

The staff also regarded the new environment as distinctly more safe (fig.112), which may explain why absence and incidents of anti-social behaviour fell rapidly in the new building.

In conclusion, whilst the limited response rate has restricted the ability to make generalisations using the BUS data, by looking at a variety of data including the attainment and attendance statistics, the limitations presented by the refurbishment in terms of construction disruption, post-occupancy energy efficiency and overheating, were generally offset by the innovative and inspiring architecture.

To help summarize the staff satisfaction results, a colour coded table has been presented.

7.4.5 BUS "Colour Coded" Summary

Variables	School A	School B	School C	School D
Air in Summer: Dry/Humid				
Air in Summer: Fresh/Stuffy				
Air in Summer: Odourless/Smelly				
Air in Summer: Overall				
Air in Summer: Still/Draughty				
Air in Winter: Dry/Humid				
Air in Winter: Fresh/Stuffy				
Air in Winter: Odourless/Smelly				
Air in Winter: Still/Draughty				
Air in Winter: Overall				
Cleaning				
Control over Cooling				
Control over Heating				
Control over Lighting				
Control over Noise				
Control over Ventilation				
Comfort OVERALL				
Design				
Furniture				
Health (Perceived)				
Image to Visitors				
Lighting: Artificial Lights				
Lighting: Glare From Lights				
Lighting: Natural Light				
Lighting: Glare from Sun and Sky				
Lighting: Overall				
Meetings Rooms: Overall				
Needs				
Noise From Colleagues				
Noise Other From Inside				
Noise from unwanted interruptions				
Noise from Outside				
Noise Overall				
Noise From Other People				
Productivity (Perceived)				
Personal Safety in Building And its Vicinity				
Space in the Building				
Space at Desk				
Storage Space: Overall				
Temperature in Summer: Hot/Cold				
Temperature in Summer: Overall				
Temperature in Summer: Stable/Varies				
Temperature in Winter: Hot/Cold				
Temperature in Winter: Overall				
Temperature in Winter: Stable/Varies				
Do Facilities Meet Needs?				

Chapter 8 Political Update

This section summarises the changing political circumstances which have shaped the development of the project's framework for Sustainable Schools.

8.1 Ofsted

Ten years ago in 2003[26], Ofsted published their first report titled, *'Taking the first step forward towards an education for sustainable development'*. At the same time the national curriculum was looking to embed the 7 key concepts outlined by the QCA (p.85). In this report, 14 primary schools, 2 middle schools and 10 secondary schools were inspected on the basis they were already embedding elements of Sustainable Development within their activities. However, they conclude by saying,

> "*Clearly, the evidence from this survey indicates that while good practice exists there is much still to do, even in these successful schools..." (p.19)*

By 2008, some 5 years later, Ofsted produced a follow up report titled, *'Schools and Sustainability: A climate for change?*'. In this inspection 41 schools were visited, resulting in a more detail analysis. Interestingly the report notes,

> "*The cross curricular approach in primary schools meant that they tended to be more successful than secondary schools in enabling pupils to explore issues from different viewpoints and to focus on the global implications of what they were learning." (p.5)*

They also acknowledge that at present (2008), insufficient effort has been made to link sustainable development with capital investment programmes such as BSF. Moreover, the report highlights how one of the aims of the BSF programme was to involve young people in designing their own school. At School A, it was observed how staff and students played a key role in determining the colour schemes throughout the internal areas of the building.

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[26] www.ofsted.gov.uk/publications/1658

Moving forwards another 3 years, by 2011, the new coalition government replaced the DCSF with the Department for Education and cancelled the BSF programme raising doubts about the way Sustainable Development will continue to influence the national curriculum. However, based on the latest Ofsted report, support for sustainable development appears to have continued, focusing less on the 8 Doorways Framework and more on the 'five principles' which the previous Labour government's 2005 report, 'Securing the Future' sets out.

- Living within environmental limits [C - Environment]
- Ensuring a strong healthy and just society [B - Community]
- Achieving a sustainable economy [E – Economics]
- Promoting good governance [or policy – see "BSF" on the SS Matrix]
- Using sound science responsibly [D - Technology]

It has also been interesting to note how these 5 principles have similar thematic relevance to the 5 dimensions set out in the current project's sustainable schools matrix. Moreover, this Ofsted report also acknowledges the continuing role ESD (Education for Sustainable Development) will play in shaping the direction of the national curriculum,

> "*Education for Sustainable Development enables pupils to develop the knowledge, skills, understanding and values to participate in decisions about the way we do things individually and collectively, both locally and globally, that will improve the quality of life now without damaging the planet for the future" (National Curriculum)*

Under the circumstances, with sustainable development continuing to influence the prevailing strategy for education, the schema below provides another visual representation of the proposed matrix, placing Education at the heart of the system.

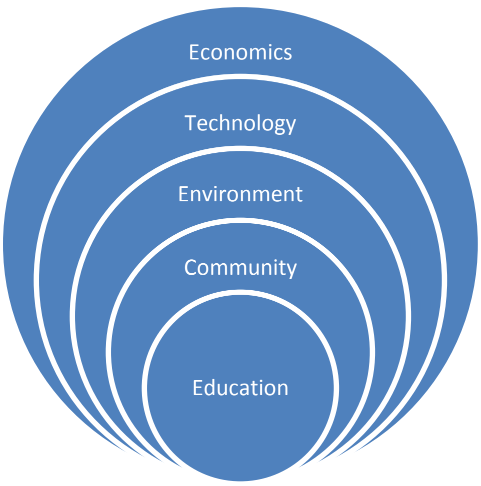

Figure 112. Schema for Sustainable Schools

8.2 Governing for the Future (SDC, 2011)

Funded by DEFRA, but acting as an independent advisory body for government, the Sustainable Development Commission (now defunct) was originally set up by the Labour government to serve as the national "watchdog" for sustainable development. Making sure government targets were achieved, and feeding back information that sought to promote a more long term national strategy, the chairman's foreword in their final report explains how,

> "*The establishment of the SDC was, in part at least, a recognition that government is not structured, or necessarily expert enough, to be able to rise above the limitations of short-term political and budgetary cycles and narrowly focused departmental remits to make the kinds of long term decisions and connected responses that these major challenges demand" (p.4, Will Day, 2011)*

This final report represents over 10 years of insight, seeking to clarify and define what Sustainable Development should mean for government policy, and how structural change in our systems of governance will be required. Consistent with the current project's attempt to link together different elements of the BSF programme, this report routinely cites the need for a "systems" approach when applying the principles of Sustainable Development.

> "*When appropriately applied, it [Sustainable Development] is a concept which allows creative thinking about the interrelatedness of complex, far reaching problems and generates new and innovative solutions. Sustainable Development is therefore a systems-based approach for achieving positive, enduring change... A systems approach does not mean tackling every aspect of a complex problem at the same time, but looking first at the big picture to identify specific steps to effect an improvement throughout the entire system." (p.2)*

Figure 113. Systems-based approach to Sustainable Development (SDC, 2011)

Unfortunately, the BSF programme was a casualty of the short-term cycle of domestic politics in the UK. It could also be argued that whilst the labour government were not properly prepared for the logistical challenges presented by the BSF programme, the coalition were equally ready to prejudge the project prior to an independent investigation.

More generally, the SDC report explains how,

> "*Progress is ensured by having built-in mechanisms to ensure continuous improvement, particularly at the end of each "cycle", where learning is reviewed, reflected upon and incorporated in the planning for the next cycle" (p.2)*

The diagram below identifies the five main barriers which the SDC encountered over the duration of their tenure (2000-2011).

Figure 114. Barriers to Embedding Sustainable Development in Government (SDC, 2011)

To varying degrees, the BSF programme was also afflicted by many of these problems. Particular issues which the research has identified include ‘an inadequate toolkit for sustainability practitioners’, as demonstrated by the lack of any substantive guidance for the post-occupancy evaluation of BSF schools.

Indeed, whilst this report declines to mention the BSF programme in name, the SDC did work in conjunction with the DCSF to produce ‘The Carbon Management Plan’ which looks specifically at ways to reduce carbon emissions in schools[27]. In this report they identify that all BSF schools would be expected to achieve a carbon emission target of no more than 40kg of carbon per metre squared. As far as the case study schools were concerned, by the third year of operation, the three new build projects were operating below 50kg/m². School D however was estimated to be in excess of 60kg/m² when the separate gymnasium was also taken into account.

From a purely educational perspective, the SDC report also explains how,

> “*... the greatest challenge was to reframe sustainable development as a positive opportunity for children and young people... eight sustainable “doorways” were chosen to cover a broad social and environmental spectrum... it urged schools to consider SD in teaching and learning, school management and community engagement... School action on sustainability made a vital contribution to local efforts to secure sustainable communities, both through tangible outcomes such as reduced carbon emissions and social cohesion, as well as through the formation of positive sustainable behaviours in young people and their families. The concept of the school as an engine of social change in communities was central to the sustainable schools vision” (p.28/29)*

In this vein, “Education” and “Community” were central to the development of the Sustainable Schools Matrix (SSM) as part of the wider challenge to link together both social and technical aspects of the BSF programme.

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[27] https://www.education.gov.uk/consultations/downloadableDocs/PDF%20Carbon%20schools.pdf

8.3 The James Review (2011)

This section provides a critical appraisal of the James Review, linking aspects of the current research to the 16 recommendations set out on the following page. In addition, a number of institutions including RIBA and the CIC have published their own response to the James Review, highlighting areas of agreement and disagreement about the proposed recommendations.

Commissioned by Michael Gove, Sebastian James was tasked with the responsibility to evaluate the BSF programme's accomplishments. However, rather than suspending BSF prior to the findings of the James Review, the government immediately cancelled the programme. As a result, six local authorities appealed this decision (Kent, Luton, Newham, Nottingham, Sandwell and Waltham Forest) and on the 11th February 2011, Mr Justice Holman ruled that Education Secretary Michael Gove had "unlawfully and without justification" failed to consult with the local authorities and had failed to give due regard to the equality impacts of his proposed decision.[28] From the original 3,500 secondary schools to benefit, only 840 projects (24%) are expected to reach completion.

In total the review identified 16 recommendations. A letter from Sebastian James to Michael Gove has also been included in Appendix A. Stand out issues include the assertion that by streamlining the procurement system, a cost saving of 30% could be achieved. To what extent this figure is based on hard and fast evidence or merely serves to justify the government's decision to "cancel" rather than "suspend" the BSF programme is unclear.

More generally, some may argue that the condition of our schools will determine our capacity to compete in the global knowledge-based economy of the 21st century. It follows that modernising our education system must be a priority..

In the sections which follow, the BSF programme has been critically appraised both in terms of the effectiveness of the procurement "processes" **[2]** as well as the operational "outcomes" **[3]**.

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28 http://www.curriebrown.com/images/projects/media/Schools%20newsletter%20-%20spring%20and%20summer%202011.pdf

Table 38. James Review – 16 Recommendations

	Recommendations
1	Capital investment and apportionment should be based on objective facts and use clear, consistently-applied criteria. Allocation should focus on the need for high-quality school places and the condition of facilities.
2	Demand-led programmes, such as Free Schools, are most sensibly funded from the centre and a centrally retained budget should be set aside for them.
3	The Department should avoid multiple funding streams for investment that can and should be planned locally, and instead apportion the available capital as a single, flexible budget for each local area, with a mandate to include ministerial priorities in determining allocations.
4	Notional budgets should be apportioned to Local Authority areas, empowering them fully to decide how best to reconcile national and local policy priorities in their own local contexts. A specific local process, involving all Responsible Bodies, and hosted by the Local Authority, should then prioritise how this notional budget should be used.
5	The local prioritisation decisions should be captured in a short local investment plan. There should be light-touch central appraisal of all local plans before an allocated plan of work is developed so that themes can be identified on a national level and scale-benefits achieved. This must also allow for representations where parties believe the process has not assigned priorities fairly.
6	Individual institutions should be allocated an amount of capital to support delivery of small capital works and ICT provision. Wherever possible, this should be aggregated up to Responsible Bodies according to the number of individual institutions they represent, for the Responsible Body then to use for appropriate maintenance across its estate, working in partnership with the institutions.
7	The Department ensures there is access to clear guidance on legal responsibilities in relation to maintenance of buildings, and on how revenue funding can be used for facility maintenance.
8	That the Department: 1. gathers all local condition data that currently exists, and implements a central condition database to manage this information. 2. carries out independent building condition surveys on a rolling 20% sample of the estate each year to provide a credible picture of investment needs, repeating this to develop a full picture of the estate's condition in five years and thereafter.
9	That the Department revises its school premises regulations and guidance to remove unnecessary burdens and ensure that a single, clear set of regulations apply to all schools. The Department should also seek to further reduce the bureaucracy and prescription surrounding BREEAM assessments
10	There should be a clear, consistent Departmental position on what fit-for-purpose facilities entail. A suite of drawings and specifications should be developed that can easily be applied across a wide range of educational facilities. These should be co-ordinated centrally to deliver best value.
11	The standardised drawings and specifications must be continuously improved through learning from projects captured and co-ordinated centrally. Post occupancy evaluation will be a critical tool to capture this learning.
12	As many projects as possible currently in the BSF and Academy pipeline should be able to benefit from the Review's findings to ensure more efficient procurement of high quality buildings. This should be an early priority to identify where this could be done.
13	That the Central Body should put in place a small number of new national procurement contracts that will drive quality and value from the programme of building projects ahead.
14	That the Department uses the coming spending review period to establish a central delivery body and procurement model, whereby the pipeline of major projects – to a scale determined by the Department – is procured and managed centrally with funding retained centrally for that purpose.
15	The Department quickly takes steps to maximise the value for money delivered though maintenance and small projects and puts in place a simple and clear national contract to make this happen.
16	That the Department revisit its 2004 Cap Gemini report and implement proposals where they are appropriate.

Source: James (2011)

From a technical perspective, recommendations 10 and 11 call for a more streamlined approach. However, opposition to the details of these proposals came from the RIBA president, Ruth Reed when she was quoted as saying[29],

> *"There is certainly a case for the standardisation **[D]** of certain elements of a school building, but the review fails to recognise that a school which is 'fit for purpose' must meet the needs of the client."*

She concludes,

> "*We urge the government to recognise the complexities in delivering the best new school buildings possible and to reject the over-simplistic approach recommended by the James Review"*

In a similar vein, the Construction Industry Council (CIC)[30] in their response to the James Review complement the BSF programme for its bold approach to design,

> *"BSF also offered the ability to investigate new layouts, better-suited to modern teaching methods, on an individual (non-modularised) basis **[D]**. This resulted in the possibility of providing inspirational, high quality, holistically-designed facilities to a higher technical standard than had been possible previously" (p.8)*

By contrast, they suggest,

> "*Modular production is not seen as the way to go. Evidence is that modular systems lead to poor quality designs, and the systems become more expensive **[E]** because of the small number of manufacturers involved in producing the system components."(p.10)*

At School A for example, important decisions about the layout etc, were taken by the practitioners. The limited budget **[E]** also ensured that conventional technologies **[D]** were adopted. As a result, the project completed 6 weeks ahead of schedule..In addition, the handover was smooth with only

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[29] http://www.basesuk.com/module/news/display/newsdisplay.aspx?news=28
[30] http://old.cic.org.uk/newsevents/CICresponse_James_Review_0910.pdf

minor defects reported post-occupancy **[D]**. This in turn enabled the re-commissioning engineer to focus exclusively on energy efficiency, identifying significant savings. Indeed, set against the tone of the government's "big society" aspiration, RIBA were understandably worried by the suggestion that staff and students should not partake in the design process,

> "*... the involvement of staff and students in brief-making is an essential element of delivering well designed buildings. We are concerned by the suggestion of the Review team that there is little value in taking this approach..."*

It was also interesting to note how the decision to create an open plan design at both School B and School C did not explicitly consider the operational needs of teaching staff **[A/B]**. As a result, the BUS survey highlighted many instances where staff were critical about the consultation process as well as the final design solution. Furthermore, the open plan layouts also increased the amount of energy required for lighting, heating and cooling **[D]**.

At School C, overheating became an issue during the construction yet no solution was put in place by the design team to remedy this problem. As a result, multiple air conditioning units were installed throughout the open plan canteen area in order to address the excessive heat caused by the high levels of solar radiation. Evidently, given that the 'curtain walling' was designed to maximise the views out into the countryside, external shading would not have been suitable. However, high specification glass (see Appendix B – Pilkington 'Suncool' **[D]**) would have been an ideal solution.

Indeed, whilst the James Review consulted with over 100 teachers, academy sponsors, architects, local authority members and builders, some of the conclusions relating to attainment were not supported by the current research,

> "(2.8) *The Review nevertheless also looked at whether [academic] performance **[A]** has improved in schools completed under BSF... we could not find any such evidence, though it is clear that it is relatively early days to make these measurements with a high degree of confidence. Some research has suggested that performance in BSF schools dipped during and directly after rebuilding as so much head teacher, and pupil time was spent worrying about building designs." (p.13)*

Across phase one, attainment rose by 25% **[A3]** following the move into the new buildings based on average grades gathered over 10 years. Indeed, whilst attainment did dip at School D during construction, this situation was aggravated by a range of mitigating circumstances **[B]**. Firstly, the school had a history of behaviour difficulties and was struggling to engage with the local community **[B2]**. Secondly, instability in terms of high staff turnover resulted in the school being placed into special measures in 2008 **[B]**. And finally, unlike the three new build projects which were built on the games fields, staff and students had to endure 140 weeks of chronic disruption **[D/B]** as the refurbishment project took shape. As a result, temporary classrooms (porter cabins) were erected around the estate. Interestingly the CIC respond to the aftermath of the BSF programme, by suggesting,

> *"If as expected, there will be more emphasis on renovation or even the refurbishment of existing buildings to be re-used as schools, planning policies and requirements such as the 'Change of Use' regulations will need to be modified..." (p.3)*

From the experience and feedback collected at School D, additional planning and preparation may be required to ensure future refurbishment projects do not overrun and cause further disruption to the schools. In addition, the regulation for refurbishment projects currently permits the full time use of windowless environments as evidenced at School D (two science labs, one office and one workshop). In light of the BUS survey, these spaces were identified as unsatisfactory, and in some cases unsafe (the reprographics room caused serious respiratory problems for 2 members of staff) **[C/B]**.

The BSF programme was also criticised by the James Review for its overly bureaucratic systems. However, as the CIC report explains, regulations were partly to blame,

> "*... when Partnership for Schools was asked to take responsibility for the design criteria for school building, there were 88 pieces of guidance on design. They said that an initial process of rationalisation had taken the number down to 40 and that currently PfS is working to get a framework of three elements to take into account." (p.3)*

Indeed, as recommendation 10 confirms, apart from streamlining the various building bulletins, 'the bureaucracy and prescription surrounding the use of BREEAM assessments' was a topic which came up throughout meetings and conversations with practitioners and business managers operating across phase one in Leicester. For example, the decision to include biomass boilers at the two PFI schools was not an integral part of the design solution. In fact, the contractor belatedly employed a specialist BREEAM consultant to ensure each design achieved the necessary points to ensure compliance. In this respect RIBA[31] agreed with the James Review,

> "*The expectation that all new schools should comply with BREEAM should be relaxed to allow for greater flexibility in approaches." (final page.4)*

Further issues associated with the protracted and cumbersome nature of the European Procurement requirement meant that multiple bid teams were invited to participate as part of the competitive bidding/tendering process. This meant that too many of the design applications were sub-standard, a problem identified during the selection process at Leicester City Council.

To compound this problem, with little independent expertise to support each school as they developed their particular "output specifications" (aka the brief), the competing consortiums (and design teams) had limited technical information through which to inform their design proposals. BSF time limitations (6 weeks) further exacerbated this situation. As a result, for all local authorities entering the second wave of BSF procurement, CABE recommended that Client Design Advisors (CDAs) be appointed to each LA in order to improve the quality of the 'output specifications' upon which the respective design applications would be judged. However, the BSF documentation still only assigned a weighting of 10% to 'design quality' as part of the selection criteria, with no mention of performance targets in relation to carbon emissions.

31 http://www.architecture.com/Files/RIBAHoldings/PolicyAndInternationalRelations/Policy/PublicAffairs/2010/RIBAresponsetoschoolscapitalreview.pdf

Obviously, the logistical challenges in terms of identifying the strongest consortium and then setting up the Local Education Partnership (LEP) was a major factor in terms of limiting the capacity to integrate energy efficiency measures across phase one. In this respect, the RIBA agreed with the majority of the James Review's findings, explaining how,

> "*The procurement process was overly complex* ***[2]****... [there was] too little expertise on the client side... [and the] regulatory and planning environment is too complex* ***[2]*** *and hostile to building new schools."*

On each count, albeit to varying degrees, the documentary evidence and observations made throughout this research tend to support this assertion.

In terms of the "operational" outcomes of the BSF programme (as opposed to the processes of procurement) the CIC's appendix documentation includes a number of letters from experts within the field of building design who also highlight the numerous technical challenges which have yet to be resolved. Dr. Dejan Mumovic (Editor of CIBSE School Design Group) for example describes the current understanding surrounding complex buildings as "remarkably underdeveloped", explaining,

> "*Although complex, achieving the balance point between IAQ (indoor air quality) and energy use is unfortunately just one of many socio-technical engineering challenges in school buildings." (CIBSE School Design Group, April 2010, p.29)*

A school is a complex and dynamic environment **[D]**. Isolating which specific factors influence the capacity for students to maximise their intellectual potential is inherently difficult. At the same time, the BSF programme's primary remit was to "transform" the learning environment in order to facilitate rising levels of attainment in communities presented with difficult socio-economic circumstances.

Indeed, by referring to the BUS database average, "perceived" productivity records a negative score, indicating how most buildings appear to inhibit staff productivity. By contrast, it was interesting to note how School A delivered a significantly positive result (+7%) in comparison.

Again, whilst this evidence is largely suggestive (rather than statistically significant or indeed causal), School A continues to perform in an exemplary fashion, demonstrating that as recommendation 11 sets out, post-occupancy evaluations are a necessary requirement in helping to identify the best educational designs.

Feeding back this critical knowledge through the creation of a national database becomes an integral part of the learning process. Indeed, once sufficient evidence has accrued which links together specific design solutions with particular settings i.e. a large school in a rural community or a small school in an urban environment; standardization through the creation of a national portfolio can be used to support architects and engineers as they develop their own solutions for a particular client/school. This in turn may reduce design costs and allow more money to be redirected towards high specification materials and low-carbon technologies **[D]** which in turn supports the drive towards greater economic **[E3]** and environmental efficiency **[C3]**.

Indeed, by developing a standard POE methodology for the evaluation of new schools, this same methodology could also be used to capture information about the existing estate. Indeed as recommendation 8 points out, the newly formed Department for Education needs to carryout independent building condition surveys in order to develop a full picture of the nation's estate over a 5 year period. Furthermore, as recommendation 1 sets out, the decision making process needs to rely on "clear and consistently applied criteria". It is therefore important to consider how a standard POE methodology may also help to objectively identify which buildings **[D]** and communities **[A/B]** should qualify to address in adequacies in the local infrastructure.

Dasgupta *et al.,* (2012), in their appraisal of the James Review remarked as follows,

> *"... setting out a new plan of action for the future.... five core objectives were identified; (1) Good value for money, helping to reduce the government's deficit; (2) Raise standards; (3) Tackle disadvantage; (4) Address building condition; and (5) Meet the requirement for school places resulting from an increase in birth rate... Alarmingly however, energy efficiency was barely mentioned throughout the report, an oversight that appears to repeat the mistakes of the past. The challenge is therefore not only to improve the technical expertise of sustainable buildings but to make aware and persuade policy makers that energy efficiency must become a core priority." (p.8)*

However, this tendency to prioritise may encourage a situation where trade-offs between competing agendas may occur. The researcher believes this is ultimately counterproductive. Instead, the 5 Capitals Framework in conjunction with a "systems" approach can help address the wider challenges presented by Climate Change and Sustainable Development.

From the researcher's perspective, the credibility of the James Review was further undermined by the limited post-occupancy data available at this time (2011). Significantly, the report pays little attention to the commissioning of the BSF schools. Indeed, as the four re-commissioning audits confirm, simply by updating the BMS control settings, a "predicted" saving of 129 tonnes of carbon was identified and then verified by examining the utlity data post-occupancy.

Chapter 9 Conclusion

This section draws to a close the major findings which have emerged following the identification of the study's 5 research objectives.

The provisional conclusion that can be drawn from this study underlines the fact that "processes" are by their nature more difficult to measure compared with quantifiable "outcomes". Nevertheless, it has been an important part of the research to look at the BSF programme holistically.

Reflecting on this journey, the first significant development was to identify an original "aim" based on the deficiencies highlighted within the literature review. On this count, it became apparent how the current thinking around Sustainable Schools has mostly been limited to individual issues failing to recognise the inter-connected and inter-dependent nature of a sustainable "system".

9.1 Objective 1: Procurement

To recap, the first objective required the researcher to familiarise himself with the BSF procurement mechanism (a "process") using the guidance literature which Partnerships for Schools developed to support Local Authorities. Moreover, as part of this investigation, it was necessary to consider to what extent Sustainable Development was an influential part of this process. Four "conditions" were then retrospectively identified, helping to shape (and clarify) the way in which the analysis was chronologically presented. As such, through combining both primary and secondary qualitative data, the analysis has taken on a more "narrative" format, helping to familiarise the reader with the particular challenges Leicester City Council were facing at this early stage in the BSF programme.

Indeed, whilst the head teachers at School A and B did suggest the consultation and design phase was successful, creating energy efficiency buildings was not a central part of this process (in part) due to the lack of operational energy targets set by the BSF design criteria. Moreover, as the business manager at School B confirmed, the original members of the Design Team were replaced once the competitive bidding process had identified the "preferred" consortium. As a result, a new relationship between the school and the new design team had to be established. Indeed, with the contractor keen to get started with construction, tensions arose when the planning department requested that alterations to the final designs would be necessary.

A = Education; B = Community; C = Environment; D = Technology; E = Economics; 1 = Inputs; 2 = Processes; 3 = Outcomes

When finally the building phase was complete, time limitations restricted the capacity to carry out an extensive (pre-occupancy) commissioning process. As a result, when operational problems emerged post-occupancy, further complications surrounding the Facility Management Contracts were reported. Indeed, whilst FM were primarily responsible for the post-occupancy management of the buildings, neither the design team or the contractor felt obliged to re-commission those services which were evidently not working properly.

Based on these circumstances, evidence gathered during the first 18 months of the research tends to suggest the BSF procurement system did not prioritise or support the development and operation of low-carbon (school) buildings.

9.2 Objective 2: Commissioning

Within a year, the council instructed an energy audit of the BMS systems. Four reports were produced, focusing specifically on ways to optimise energy efficiency. Indeed, as the half-hourly analysis of electricity consumption helps to confirm, all four buildings were generally operating more efficiently as a result of the various modifications. In most instances, timer settings were adjusted to operate more tightly around opening hours. In the canteen for example, air conditioning units were reprogrammed to operate around the lunch break (12 noon to 2pm).

From an energy perspective, these reports highlight the failure of the contractor to properly commission each building prior to occupation. Furthermore, with the online database not working due to a range of hardware and software issues (due to the inadequacy of the pre-occupancy commissioning), the FM provider was unable to accurately monitor the four buildings. From the researcher’s perspective, this was also problematic as the data he had expected to collect was not available.

Other problems to do with inconsistencies between the ‘as fitted’ drawings and the constructed building resulted in a range of comfort issues linked to the HVAC systems. At School D for example, a number of rooms appeared to have no extraction although the ‘as fitted’ drawings suggested otherwise. At School B, the ‘black button’ ventilation system appeared to trigger multiple classrooms simultaneously. At School C, classroom thermostats were in some cases controlling different rooms. Indeed, with the FM provider playing only a minimal role in the design and construction phase, they were not well equipped to then re-commissioning these services post-occupancy.

A = Education; B = Community; C = Environment; D = Technology; E = Economics; 1 = Inputs; 2 = Processes; 3 = Outcomes

Notably, it was only at School A where minor problems were reported. As a consequence, the re-commissioning audit was able to focus exclusively on reducing energy consumption, identifying 41 tonnes of carbon savings, equivalent to a 10% reduction. Indeed, as the 2010 FM report identifies, School A had the most efficient heating system based on degree-day analysis (0.97).

Evidently, the original commissioning was inadequate both in terms of energy efficiency as well as environmental comfort. The re-commissioning reports have identified substantial savings which the operational data has now confirmed. However, it has not been possible to re-evaluate how these adjustments may have improved environmental comfort. In this regard, it would be helpful if staff were to complete a second occupancy satisfaction questionnaire.

9.3 Objective 3: Energy Efficiency

The first part of this analysis considered the construction and specification of the buildings. The second part of this analysis looked specifically at the utility data. In both respects it has been helpful to consider the information contained within the "sustainability matrix" (see Appendix B) as a way to evaluate and compare the performance of the four schools (see table 40).

Table 39. Building Performance Summary (*excludes biomass; # excludes gymnasium)

	Good Practice	School A	School B #	School C #	School D *
Pupil Numbers	-	1,050	1,300	1,200	900
Project Type/Finance	-	New Build/D&B	New Build/PFI	New Build/PFI	Refurb/D&B
Project Cost	-	£15 million	£21 million	£19 million	£12 million
Open Plan	-	No	Yes	Yes	No
Floor Space	-	10,500	13,000	12,000	10,250
Basic Construction Materials	-	Steel Frame Concrete Floors Steel roof	Steel Frame Concrete Floors Steel roof	Steel Frame Concrete Floors Steel roof	Steel Frame Concrete Floors Steel roof
Swimming Pool	-	No	No	No	No
Gymnasium	-	Yes	Yes	Yes	Yes *
Heating System	-	Gas	Biomass + Gas	Biomass + Gas	Gas
Carbon Emissions	40 $kgCO_2/m^2$	46 $kgCO_2/m^2$	42 $kgCO_2/m^2$	49 $kgCO_2/m^2$	44 $kgCO_2/m^2$
Heating Load	79 $kWh/m^2/yr$	89 $kWh/m^2/yr$	90 $kWh/m^2/yr$	90 $kWh/m^2/yr$	70 $kWh/m^2/yr$
Electrical Load	54 $kWh/m^2/yr$	64 $kWh/m^2/yr$	61 $kWh/m^2/yr$	63 $kWh/m^2/yr$	59 $kWh/m^2/yr$
U-value Wall U-value Window U-value Roof U-value Floor	0.35 2.2 0.2 0.25	0.27 1.8 0.16 0.2	0.27 1.8 0.16 0.2	0.26 1.8 0.16 0.25	0.28 1.75 0.2 0.25
Airtightness Test	< 10 $m^3/m^2/hr$	4.74 $m^3/m^2/hr$	5 $m^3/m^2/hr$	4.68 $m^3/m^2/hr$	-
HVAC System	Nat + A/C + Mechanical	Nat + A/C + Mechanical	Nat + A/C + Mechanical	Nat + A/C + Mechanical	Stack + A/C + Mechanical
Water Consumption	2.7 m^3	2.37 m^3	2.29 m^3	2.27 m^3	2.57 m^3
BREEAM Rating	-	Excellent	Excellent	Very Good	Very Good
Efficiency Savings	-	52 tonnes	48 tonnes	16 tonnes	80 tonnes
Annual Emissions	-	496 tonnes	556 tonnes	589 tonnes	460 tonnes
2012 DEC Ratings	-	C (75)	C (68)	D (81)	C (68)

* Emissions associated with the existing gymnasium, a separately metered building, have not been included.
# Woodchip Emissions have not been included due to the intermittent use of the biomass systems.

A = Education; B = Community; C = Environment; D = Technology; E = Economics; 1 = Inputs; 2 = Processes; 3 = Outcomes

Interestingly, by comparing the four schools with the 'Good Practice' figures, whilst specifications (U-values and Airtightness) were notably better, the operational data in terms of carbon, heating and electrical performance were not as good. More generally, these findings demonstrate how operational performance often lags behind energy predictions based on design specifications (something which BREEAM only considers at this present time).

In the future, if financial penalties are to be avoided when operational targets for energy performance become mandatory, the developers (namely, the design team, contractor, component manufacturers and FM services) will need to operate more effectively as a 'team' to ensure their products and services are more efficient and effective.

Across phase one, the contractor's primary concern was to comply with the BREEAM design quality requirement. As such, the BREEAM points system had a limited role in terms of incentivising the design team to create operationally efficient buildings across phase one. Moreover, the decision to adopt biomass as a viable alternative to natural gas has not been successful in terms of reducing operating costs and carbon emissions. Moreover, the logistical problems in terms of woodchip delivery and storage, coupled with the sluggish response time of the underfloor heating system, has had a negative impact in terms of environmental comfort. As a result, the buildings were frequently unable to respond in a timely fashion when the outdoor temperature changed rapidly over the course of a day. By extension, staff who completed the occupancy survey were openly critical about the way the buildings failed to deliver the stable and comfortable conditions which had been expected.

9.4 Objective 4: Occupancy Satisfaction

Without reproducing the various summary graphics already presented, the occupancy satisfaction survey helps to underline the importance of delivering a comfortable building across a range of conditions. Conventional buildings are generally easier to commission, requiring less onsite expertise. In contrast, complex buildings require a thorough and extended commissioning phase. In secondary schools where hundreds of children are present, pre-occupancy commissioning becomes even more critical.

To support this position, it was interesting to discover how School A was clearly the most successful school based on the Likert scale data. A quick glance down the respective columns of the colour coded summary table validates this assertion by the higher frequency of green and amber boxes. The Spider Diagram also provides another illustrative example, identifying the consistently high scores across the main variables (Comfort, Lighting, Design, Needs, Health etc).

9.5 Objective 5: Educational Transformation

This fifth and final objective which the research has attempted to address was discretionary insofar as the term “Educational Transformation” was not accurately defined as part of the BSF programme. However, by examining over 10 years of data, it became possible to both define and then measure the extent of transformation observed.

Looking first at the Ofsted reports, the analysis was able to present a contextual picture of the schools and their surrounding communities. This information also helped to explain why the schools were invited to participate in phase one of the BSF programme. As expected, all four schools demonstrated a range of social, educational and infrastructural challenges which could now be addressed through the BSF programme.

Examination of the statistical data which relates to the percentage of students who qualify for free school meals (FSM) further illustrates this situation, showing a gradual rise over 10 years across all 4 schools. Moreover, the number of children who were identified as SEN (Special Educational Needs) also marginally rose.

Interestingly, the analysis integrates an anecdotal account of the KIPP schools in America, supported by statistical evidence, as highlighted by Gladwell (2010) in his book “Outliers”. This simple analysis attempts to highlight the link between ‘learning time’ and ‘academic performance’. Children from disadvantaged backgrounds have fewer opportunities to learn, be that in the classroom or at home. The conclusion has therefore been to create a “culture” where children are motivated to commit more of their time to their studies. At the KIPP schools, longer days and homework clubs helped facilitate this process. Furthermore, students and parents were obliged to sign a contract with the school to confirm their commitment to this philosophy. At the BSF schools, whilst this was not an explicit aim, truancy/absenteeism had reduced and the evidence pointed towards a situation where the physical environment was no longer a disincentive or barrier to their learning. On the contrary, the new buildings, supported by an extensive array of ICT, were helping to improve behaviour and engage students in the cumulative day to day learning process.

Looking at GCSE examination performance clearly demonstrates the dramatic improvement in attainment.

A = Education; B = Community; C = Environment; D = Technology; E = Economics; 1 = Inputs; 2 = Processes; 3 = Outcomes

Parental engagement was another important aspect which the researcher endeavoured to consider. Fortunately, the Ofsted reports contained important data about the opinions of parents. 8 questions were subsequently identified and assigned a theme. It has then been possible to examine how attitudes have changed over a 10 year period. Significantly, as the simple subtraction methodology helps to confirm, parents' perceptions of the schools improved. Most notably, "Communications" improved by 15% (possibly due to the expanding use of e-mail, ICT and mobile smart phones).

Finally, it has now been important to revisit the occupancy satisfaction data for further evidence that the new buildings were helping to support staff. As can be seen below, the major questions often produced more positive response scores,

- Q. Do Facilities Meet Needs ?
  - *School A – **Green**; School B – **Green**; School C – **Amber**; School D – **Amber**.*
- Q. All things considered, how do you rate the building design overall?
  - *School A – **Green**; School B – **Green**; School C – **Amber**; School D – **Green**.*
- Q. All things considered (air quality, temperature, lighting etc) how do you rate the overall comfort of the building?
  - *School A – **Green**; School B – **Green**; School C – **Green**; School D – **Green**.*
- Q. Please estimate how you think your productivity at work is decreased or increased by the environmental conditions in the building?
  - *School A – **Green**; School B – **Amber**; School C – **Amber**; School D – **Amber**.*

9.6 Project Aim: Applying the Sustainable Schools Matrix

Throughout the analysis chapters the researcher elected to identify the five themes by the letters **[A], [B], [C], [D],** and **[E]**. Due to the extended breadth of the analysis however, it was deemed not practical to identify and discriminate between the inputs **[1]**, processes **[2]** and outcomes **[3]** during the analysis chapters. In this section each school will be appraised separately with the intention to apply all 15 aspects of the matrix to the analysis. It should also be noted how the "outcome" of one dimension may also serve as the "input" of another dimension. Take for example savings from energy efficiency **[E3]**; this may allow more money to be spent on hiring teachers or support staff **[A1].** Crucially, it is the realisation that each and every school is unique and dynamic that makes this approach novel and insightful.

The Sustainable Schools Matrix has now been applied to each school separately. The header above also helps to remind the reader about the 15 classifications from **[A1]** to **[E3].**

9.6.1 School A

At School A the Ofsted reports highlight the challenging socio-economic circumstances affecting the school **[B1]**. As a result, attainment on entry to the school was significantly below the national average **[A1]**. The old school was also described as "inadequate", identifying a lack of ICT **[D]**. Furthermore, staff turbulence **[B2]** was identified as the principle cause for the drop in attainment during 2004 and 2005 **[A3]**.

Following the move into the new building however, the 2010 Ofsted report highlights how incidents of bullying had decreased **[B3]**. To what extent this can be linked to the physical environment **[C/D]** is not clear, although the smart card cash-free technology **[D]** has now removed the opportunity for theft related bullying.

Rising levels of attainment were also considerable. From 2002 to 2009 only 46% of students achieved 5 or more GCSEs at A to C **[A3]**. From 2010 to 2012, this had risen to 73% **[A3]**.

From the results obtained through parental comparison surveys **[B3]**, one significant rise in performance (10%) was "happiness" based on the question(s), 'My child likes school (2002); My child enjoys school (2010)'. Other areas where marked improvements were identified include, Behaviour (12%) and Communication (18%).

A = Education; B = Community; C = Environment; D = Technology; E = Economics; 1 = Inputs; 2 = Processes; 3 = Outcomes

Looking specifically at the BUS data it was evident how positive **[B3]** staff felt about the new building. At School A, the intangible value of allowing staff and students to select the colour of the internal decor was important for building trust. Indeed, the "perceived" increase in productivity **[A3]** was +7.86% which compares favourably to the BUS database average of – 2.03%.

Finally, the anecdotal evidence suggests that both contractor and school were broadly satisfied with the way the project had been managed. Indeed, from an energy/environment perspective, early indications (based on the first 3 years) suggest the building was performing well, although electricity consumption was higher than the other three schools at 64 kWh/m²/yr. Moreover, if the calculations produced by the Thorlux report are assumed to be correct, upgrading the lighting could potentially reduce this electricity demand by a further 25%. Unfortunately, the contractor was not contractually obliged to achieve a specific operational efficiency target for electricity consumption.

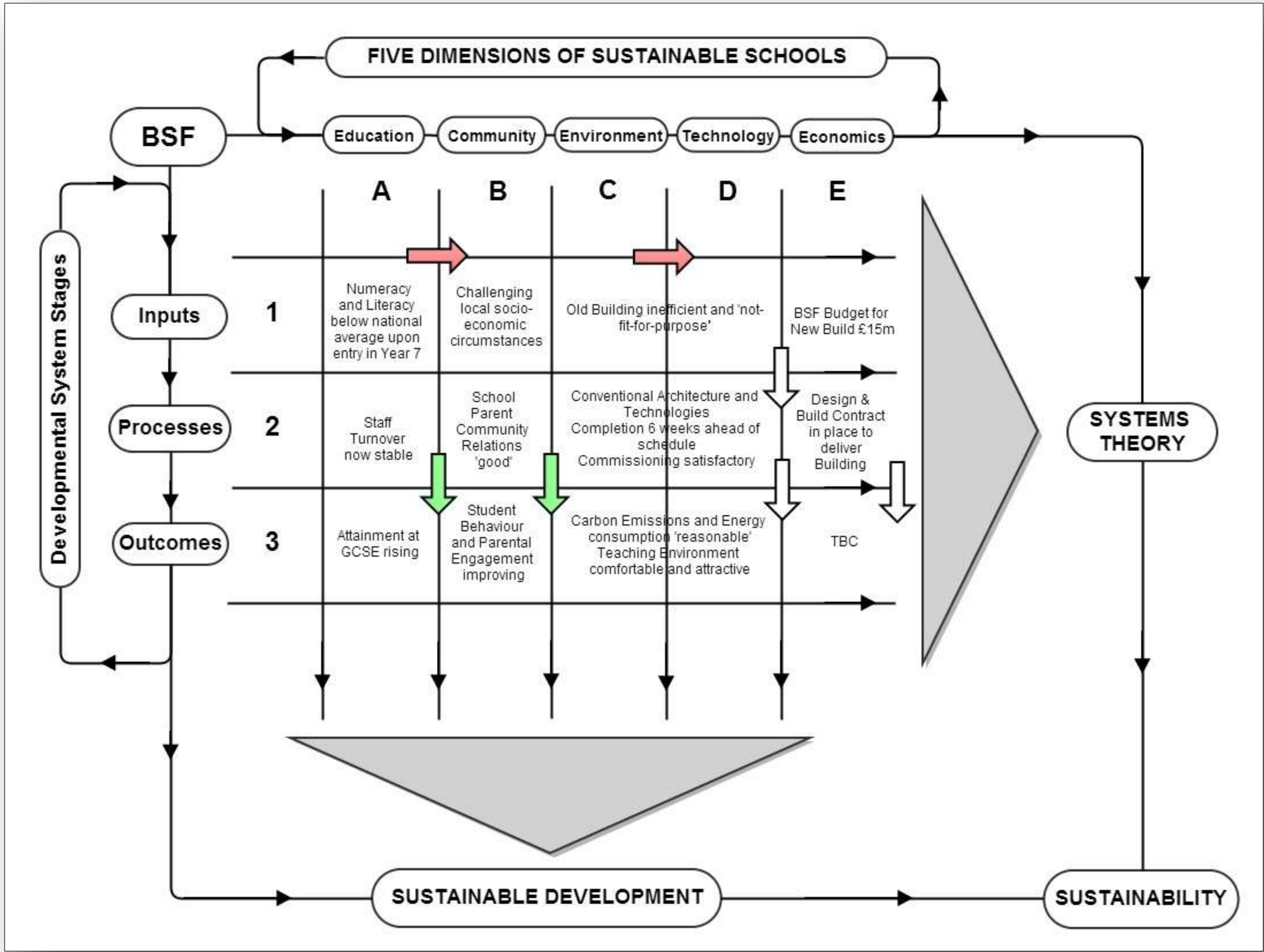
On the following page the relationships between the social and technical circumstances have been entered onto the matrix in order to highlight the connectivity and relationships which exist. between the various themes and circumstances. Importantly, as a result of the committed efforts by the school's senior management to stabilise turnover, the infrastructural improvements were able to enhance the performance of the school across a number of criteria (attainment, behaviour etc). The relatively modest budget of £15m also demonstrates value for money was achieved for a new build project.

Further research may wish to develop a standard formula for calculating 'value-for-money' over an extended time period (3, 5, 10 years) based on variables such as capital costs, running costs, carbon emissions, attainment, attendance and community use etc.

In conclusion, School A demonstrates that simple buildings which are properly commissioned produce stable and predictable results in terms of utility performance, comfort and occupancy satisfaction.

A = Education; B = Community; C = Environment; D = Technology; E = Economics; 1 = Inputs; 2 = Processes; 3 = Outcomes

Figure 115. Applying the Sustainable Schools Matrix to School A



A = Education; B = Community; C = Environment; D = Technology; E = Economics; 1 = Inputs; 2 = Processes; 3 = Outcomes

9.6.2 School B

School B was the largest and most expensive (£21.5m) of the four phase one schools **[E1]**. As a result, the researcher looked at the BB98 guidance documentation for information that relates to pupil numbers and floor space. As he discovered, all three new build schools were approximately 25% larger than the recommendations **[D]**. However, whilst this extra space at School A extended the teaching and working environment, at School C and B, the open plan designs were mostly redundant. Indeed, these spaces also needed to be heated. It was also therefore doubtful whether the 2% natural light requirement (for non-teaching space) had been achieved at School B.

With hindsight, not only was energy efficiency a causality of the open plan design approach, but the limited space for teachers to socialise in staff rooms had a negative impact on their feelings towards the new building's **[B3]** inefficient use of space. Indeed, had School A opted for a similar open plan design, the contrast in attitudes (from the BUS survey) may have gone unnoticed.

Looking now at School B's social and education circumstances over the past 10 years, the Ofsted reports identify how 80% of students are from Indian heritage **[B1]**, many of whom are fourth generation British Asians. In 2001 the school was criticised for a lack of leadership and the inability to effectively communicate with parents and the surrounding community. It was further noted how the previous building and campus was often the site where anti-social behaviour would occur. Dog fouling and joy-riding were reported, highlighting the wider social problems **[B2]** which needed to be addressed.

By 2007 however, the Ofsted report identifies a marked improvement in the senior management following the appointment of a new Head Teacher. As a result of a range of initiatives to promote competitive sport and academic excellence, both attainment and behaviour began to improve. Previously, from 2002 to 2009, 62% **[A3]** of students achieved 5 or more GCSEs at A to C grade. From 2010 to 2012, this figure had risen to 87% **[A3]**. It was also noted how in 2012, attendance had risen to above 95% **[B3]**.

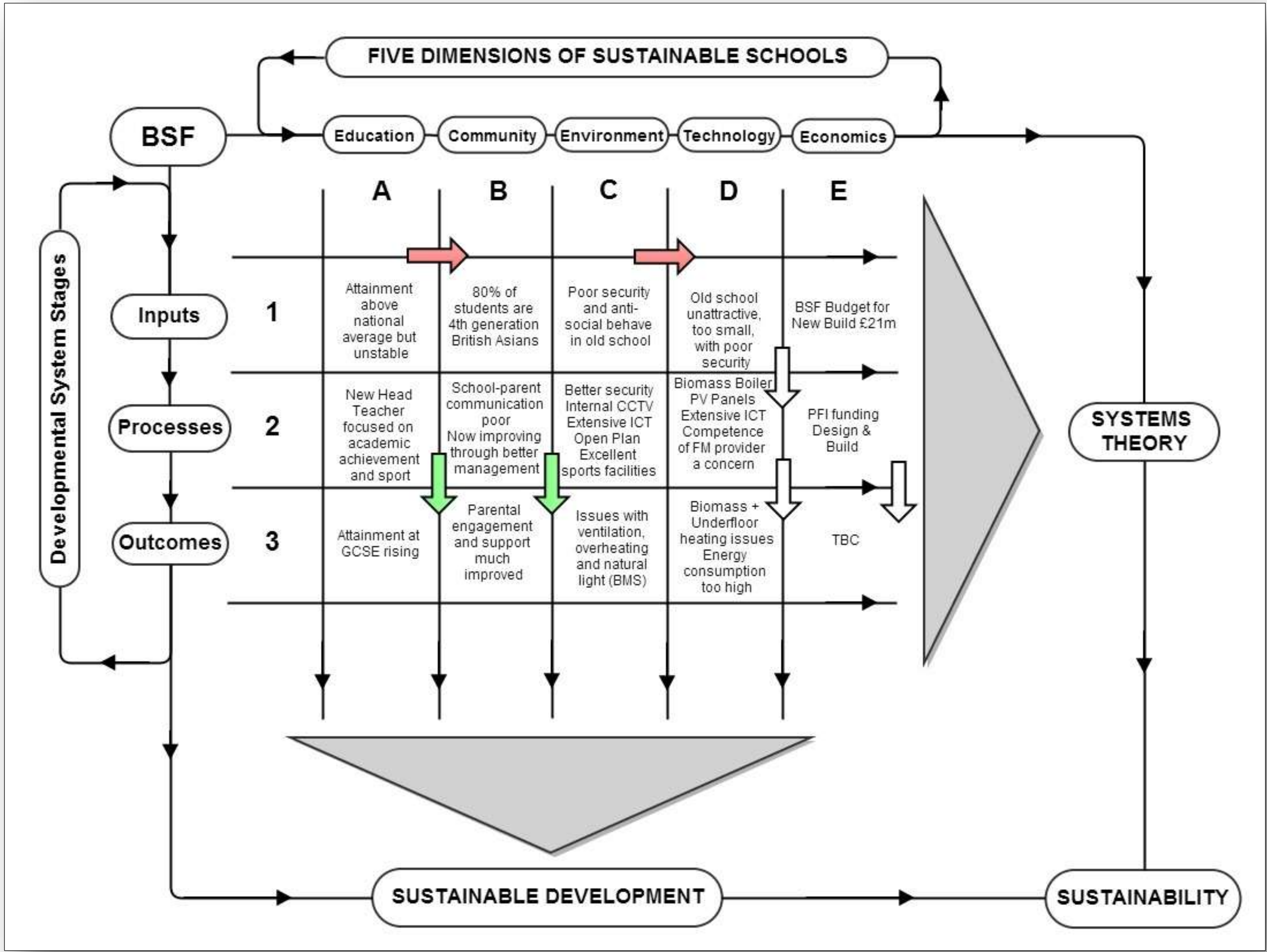
To support this upward trend in educational and behavioural improvement, it was significant to discover how parental attitudes were dramatically improved across the 8 themes (+16%) with 'Leadership & Management' and 'Student Welfare' producing the greatest gains of 25% and 27% respectively **[B3]**.

Interestingly, the BUS data illustrates a mixed picture. On the one hand, the likert scale data confirms how environmental conditions were unsatisfactory. This by extension highlights the need for thorough and continual commissioning of the HVAC system. By contrast, scores for “overall comfort” **[B3]**, “building design” **[D3]** and “Do the facilities meet your needs” were more positive **[A3]**. It seems therefore, whilst staff were disappointed by the environmental conditions, they were also prepared to look beyond these (temporary) issues to the wider benefits and opportunities the new facility could now provide.

On the following page, the matrix has been populated with key information about the prevailing circumstances which characterise this particular project. Particular issues include the inadequate security in the old building and the failure by senior management to communicate with parents. On both counts, the catalytic effects of the new building appear to have made a positive contribution. Unlike school A however, technical issues associated with the heating systems and the general comfort of the building have undermined (optimal) performance across the 5 dimensions. Moreover, with the project costing £21m, it is not clear whether the additional expense to include underfloor heating and an open-plan layout deliver value for money all things considered. Moreover, from a strictly environmental perspective, the biomass systems were unable to deliver the expected carbon and financial savings.

A = Education; B = Community; C = Environment; D = Technology; E = Economics; 1 = Inputs; 2 = Processes; 3 = Outcomes

Figure 116. Applying the Sustainable Schools Matrix to School B



9.6.3 School C

At School C, the Ofsted report identified that approximately 60% of students do not speak English at home **[B1]**. This has created a challenge for staff as it has meant more resources are required to raise literacy skills from year 7 onwards **[A2]**. In the old building, ICT was limited to a single windowless room that was servicing 1200 students **[D/A]**. As a result, students had limited access to the internet which in turn had a negative impact on the wider curriculum. **[A2/3]**.

Interestingly, when the new languages block was completed in 2004, the 2010 Ofsted report highlights how 63% of students now achieve at least one GCSE grade A to C in a modern foreign language compared with the national average of only 28% **[A3]**.

More recently, the 2011/2012 prospectus identifies how the school is currently oversubscribed by a factor of 3. Evidently, parents were keen for their children to attend School C, underlining the school's exemplary reputation in the community **[A3/B3]**.

Looking now at the changing levels of attainment over the past 10 years, from 2002 to 2009 the average number of children achieving 5 GCSEs at A to C was 58% **[A3]**. From 2010 to 2012, this had risen to 67% **[A3]**. Interestingly, when the parents responded to the Ofsted question, 'My child is making good progress in school (2002); my child is making enough progress at this school (2010)' their response scores indicated a marginal reduction in perceived attainment (minus 4%). At the same time, parents were noticeably more supportive of the school (+19%) in terms of the way 'communications' were now being managed **[B]**.

From a design perspective, the BUS data confirms how there were many complaints about the building's storage capacity **[D]**. Furthermore, the staff room and departmental areas were criticised, raising concerns about the decision to create an open plan environment. Overheating was also another problem which had caused significant disruption during the 2010 summer term. In addition, the governors and the local authority were now concerned about the running costs associated with operating the new school based on initial bills which appeared to indicate a tripling of costs (when compared with the old building).

From a procurement and design perspective **[D2/E2]**, School C and B used the BSF-PFI funding mechanism. It was also decided that biomass would replace conventional gas as a way to satisfy both the BREEAM requirement **[D2]** as well as the local authority's 11% onsite renewables policy. As a result, the biomass "portfolio" strategy was expected to save in the region of 200 tonnes of carbon per year based on an annual emission rate of 2000 tonnes across all four schools **[C3]**.

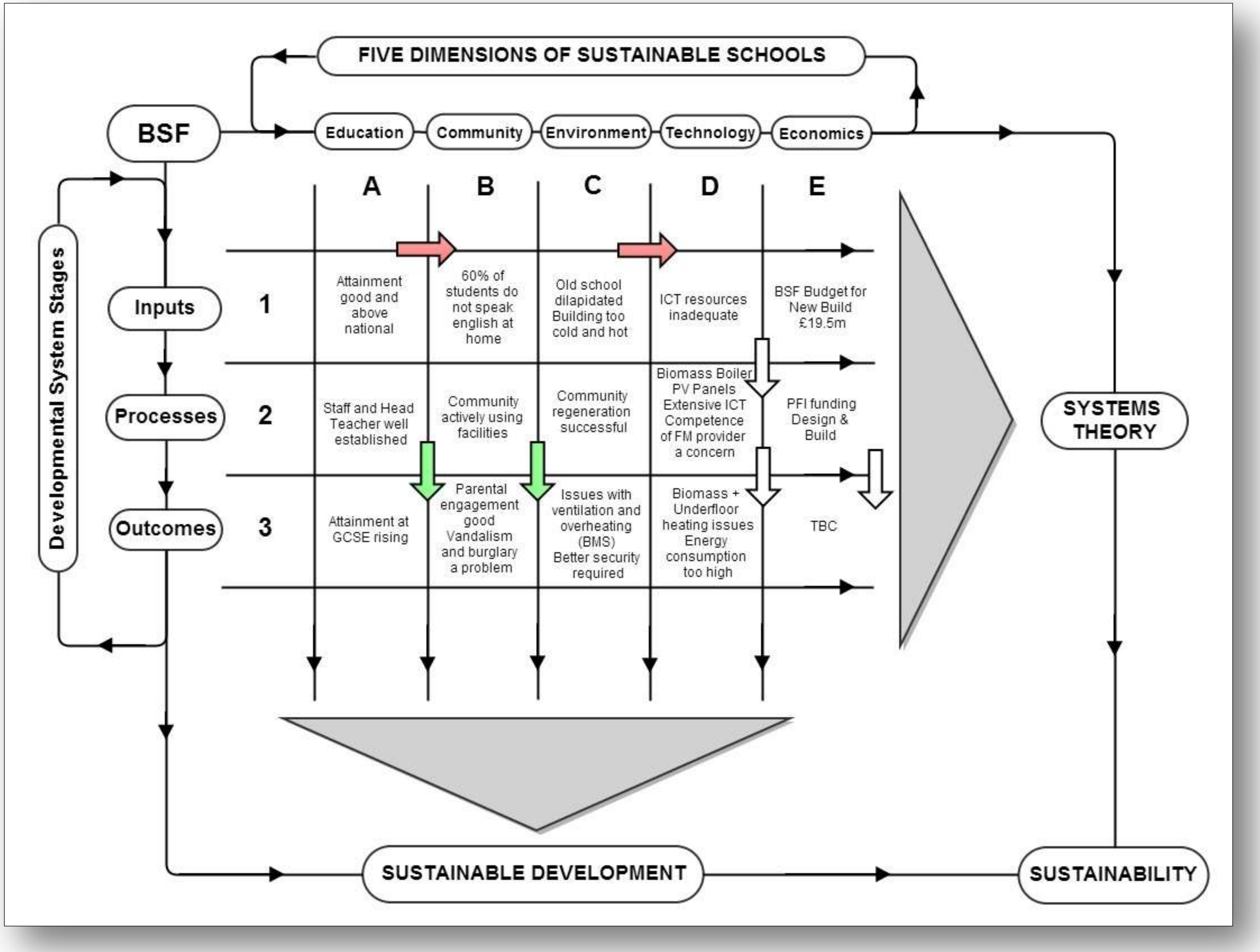
Unfortunately, due to a range of commissioning and operational problems, the biomass boilers were temporarily de-commissioned during 2010 and 2011. Indeed, as more information became available, further complications associated with the delivery and storage of woodchips became a problem **[D]**. Moreover with both schools electing to adopt underfloor heating, the heating system was too slow to respond when outdoor temperatures fluctuated over the course of a day **[D]**. Furthermore, with gas prices undercutting the cost of woodchip, any financial savings associated with biomass were becoming less likely **[C3/E3]**.

On the following page, the matrix identifies how this particular project was already performing well in terms of academic attainment. However, the old school was particularly rundown which was having a negative impact on student-teacher morale. Evidently, the regeneration of School C was specifically motivated by the need for infrastructure renewal. However, it was decided at the design stage that security fencing should be kept to a minimum. Unfortunately, after a number of break-ins, the business manager now accepts this was a mistake. As a consequence, timer settings for the outside (security) lighting were modified to remain on throughout the night, which in turn had a knock-on effect for electricity consumption and the associated emissions.

Similar to School B, the budget of £19.5m was used to create a more open-plan design. Again, it is not clear whether this type of design delivers value-for-money all things considered. In the future, more research linking layout arrangements with energy consumption, academic performance and behaviour outcomes may be necessary.

A = Education; B = Community; C = Environment; D = Technology; E = Economics; 1 = Inputs; 2 = Processes; 3 = Outcomes

Figure 117. Applying the Sustainable Schools Matrix to School C



9.6.4 School D

School D was a refurbishment project **[D]** with a limited budget of £11m **[E1].** At the same time, the school was experiencing a higher level of disruption caused specifically by the construction works. To aggravate this situation, the school had a wide range of social challenges, including high staff turnover, truancy and declining levels of attainment **[B/A]**. The local community were also experiencing a range of demographic changes following the expansion of the European Union in 2004. **[B2].**

In the 2005 Ofsted report, the inspector highlights the failure of parents to support the school through ensuring their children attend regularly and complete their homework . At the same time, the inspector was equally critical about the inconsistent quality of teaching **[A2]**. Furthermore, poor behaviour by a minority of children was having a negative impact on the school's wider reputation within the local community **[B2]**.

Initially a 'revised behaviour policy' **[B2]** was seen to be working according to the 2006 Ofsted report. However, by 2008, School D was not making sufficient progress and was placed under 'Special Measures'. This also involved replacing the board of governors which in turn created further uncertainty about the school's future.

Unlike the previous three schools, School D was a 1930s redbrick building that was built to accommodate 450 girls. By 2008, the school was now struggling to accommodate 900 boys and girls, twice as many pupils as the building had originally been designed for. As a result, Games and PE lessons were almost impossible to carry out. Girls in particular, mainly due to a lack of changing room facilities, rarely participated. However, by 2004, the building received additional funding of £1.5m **[E1]** to construct a new gymnasium **[D]**. This had a positive impact on the school, allowing students to enjoy at least 2 hours of PE per week **[A3]** as well as compete in local sporting leagues **[B3]**.

Moving forward to the point when the refurbishment was finally complete **[D3]**, the school was now in a position where the foundations for educational **[A]** and social **[B]** improvement could begin. Looking now at the statistical data for evidence of this change, from 2002 to 2009 only 32.5% of students achieved 5 or more GCSEs at A to C grade. Indeed, whilst 2010 achieved a marginal improvement of 37%, by 2011 a new head teacher was successfully recruited. In 2011, 79% of students achieved 5 or more GCSEs, and by 2012, this figure had jumped even higher to 94%. To further underline the reversal in fortunes based on the statistical evidence, student absenteeism increased to an alarming 20% during the construction phase (2007-2009)**.** However, by 2012, this had reduced to approximately 8% **[B3]**.

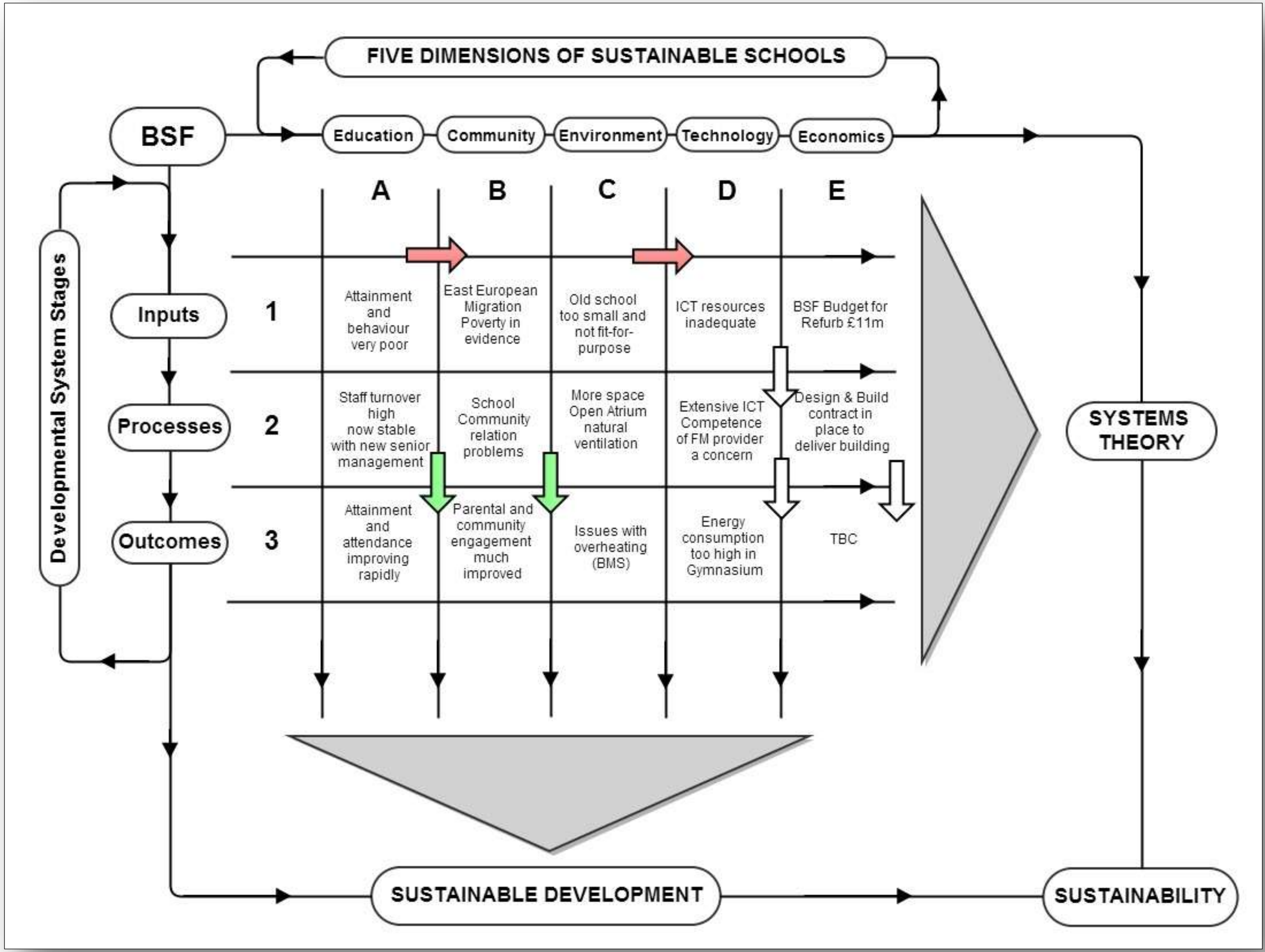
Indeed, whilst there was no available (Ofsted) data to compare how parental attitudes may have changed over the intervening years, the documentary evidence contained within the 2010 Ofsted report highlights a range of initiatives which the new head teacher had successfully implemented. Firstly, a fund was setup to support children from the poorest families **[E/B]**. Secondly, a new school uniform was helping to rebuild the school's reputation and identity within the community **[B2]**. Students were also prevented from leaving the premises at lunch times, resulting in a dramatic reduction in complaints by local residence **[B3]**. This was made possible by the increased size of the new building in addition to the extensive range of ICT resources and indoor and outdoor social spaces **[D].**

Looking finally at the environmental performance of the building in terms of energy efficiency **[D3]** and carbon emissions **[C3],** it was apparent how much energy the gymnasium used per metre square (m^2) compared with the main building. Indeed, since these buildings were metered separately (apart from water consumption), whilst the refurbished school operated at a comparable level to the three new build projects, when combined with the gymnasium, overall emissions increased substantially. It may therefore be necessary to consider how additional efficiency measures can be applied to the gymnasium.

Looking now at the matrix, whilst this framework does not set out to include an exhaustive presentation of the detail of each school, as school D helps to illustrate, demographic changes and the impact of localised poverty were having a destabilising effect on attainment and behaviour. This was further compounded by the old building's inability to comfortably accommodate 900 students and the subsequent disruption of the refurbishment activities.

From a financial perspective, the £11m set aside to redevelop the existing 1930s infrastructure provided both value-for-money and reduced the amount of embodied energy that would have been consumed in a new build project. In this regard, the project was sustainable from an environmental perspective. Furthermore, whilst comfort issues associated with a poorly commissioned HVAC system did cause problems, the broader success of this project should not be underestimated. Attainment and behaviour improved beyond recognition and the energy efficiency of the main building (exluding the gymnasium) was on par with the new build projects.

Figure 118. Applying the Sustainable Schools Matrix to School D



9.7 Summary

Sustainable Development is an inherently complex idea which requires a balanced and sophisticated understanding of the numerous socio-technical challenges presented by Climate Change. In this regard, the Sustainable Schools Matrix has proven to be a helpful illustrative device when attempting to highlight the context-dependent nature of a school. Furthermore, with the majority of findings demonstrating a consistent improvement across all four schools, on reflection phase one, with a budget of £65m, was successful both in terms of value-for-money and fit-for-purpose design.

However, the anecdotal evidence would suggest the procurement mechanism was unable to manage and resolve the various conflicts of interest which arose, which in turn had a negative impact on the performance of the FM provider post-occupancy. In terms of reforming the present regulatory system, table 40 (see p.324) provides a comprehensive set of recommendations which to varying degrees the present research findings also validate and support. Prime examples, quoted verbatim, include;

1. *Greater incentives and penalties should be introduced to ensure the improved ways of delivering sustainable facilities are driven through.*
2. *Evidence of integration and collaborative working should be part of the best value review process in the public sector.*
3. *There is a need for a network to advise the public sector about assembling integrated construction project teams...public sector selection procedures should incorporate weightings that favour firms that have invested in sustainable and renewables technologies and can show evidence of waste reduction within their business.*
4. *Integrated teams should manage cost collaboratively to ensure all members of the team are incentivised by efficiency gains.*
5. *The Integrated team must stand by its product and provide training and support to ensure end users gain the maximum operational benefits and performance improvements.*
6. *Greater flexibility in the treatment of capital and revenue budgets is required in the public sector to encourage long-term thinking and capital investment in more sustainable facilities.*
7. *Lead contractors should ensure the whole integrated supply team is aware of specifications and targets, and must avoid substituting inferior products that jeopardise long term performance.*

So finally, is it possible to measure the extent to which a school is sustainable? Well ‘yes’ and ‘no’. Initially, in the absence of clear and reliable data, yearly snapshots of performance are less helpful. Over the course of time however, when more data becomes available, a longitudinal analysis that includes the full spectrum of data (quantitative, qualitative, social, educational, energy etc) will help determine each schools’ sustainable credentials across the 5 dimensions identified by the SS matrix.

Chapter 10 Final Discussion

This section looks at how the findings and general approach adopted throughout this research can be used to influence and improve future construction projects. It has also been recognised that achieving more sustainable outcomes will rely on the ability to improve coordination across the public-private-partnership. Indeed, by attributing individual and shared responsibility to stakeholders based on the classifications [A1-E3] set out on the SS matrix, a more connected and transparent mode of working may help to bridge the disciplinary divides which currently exist.

10.1 Refining the Sustainable Schools Matrix

As the coding system has demonstrated, considerable insight can be gained by connecting together different elements of the matrix. However, as the researcher has begun to reflect on this framework, it has become apparent where additional refinements may still be necessary.

Take for example the third dimension; “Environment”. In some situations this has been associated with the broader picture concerning carbon emissions and pollution. At the same time, each schools’ internal environment was considered as part of the occupancy satisfaction questionnaire. It may therefore be necessary to adjust dimension “D” so it includes “Carbon & Technology” which in turn focuses dimension “C” exclusively on the “built” and “natural” environment.

Another issue which arose which the matrix failed to address was the uncertainty surrounding government policy, building regulations and operational contracts. A 6th dimension, possibly termed “Governance”, may be necessary when referring to the policies and initiatives which give rise to infrastructural investment. The BSF-LEP procurement mechanism would be one such example. Likewise, PFI or D&B contracts would also form part of this additional “dimension”.

Finally, behaviour issues were linked to the 2nd dimension, ‘Community’. This again may need to be revised since pupil behaviour in the classroom may wish to be linked to ‘Education’. It then becomes more simple to link classroom CCTV [D - Technology] for example to behaviour and attainment [A - Education] data. Indeed, given that the School B spent £30,000 of their own financial budget to install internal CCTV, is it not time for all schools, new or old, to be fitted with similar video monitoring systems to address disciplinary problems?

10.2 Integrated working and suggestions for the future

As the mind-map in chapter one helps to illustrate, in a project as challenging and complex as the BSF programme, the ability for private and public sector workers to cooperate and communicate as a “team” is essential for the delivery of efficient and sustainable products (and services). Moreover, as the construction industry gets to grips with the pressing need for continual commissioning and customer support (via the FM providers), so again the need for shared responsibility and cross-disciplinary working becomes ever more important.

In the diagram below, three types of working have been presented.

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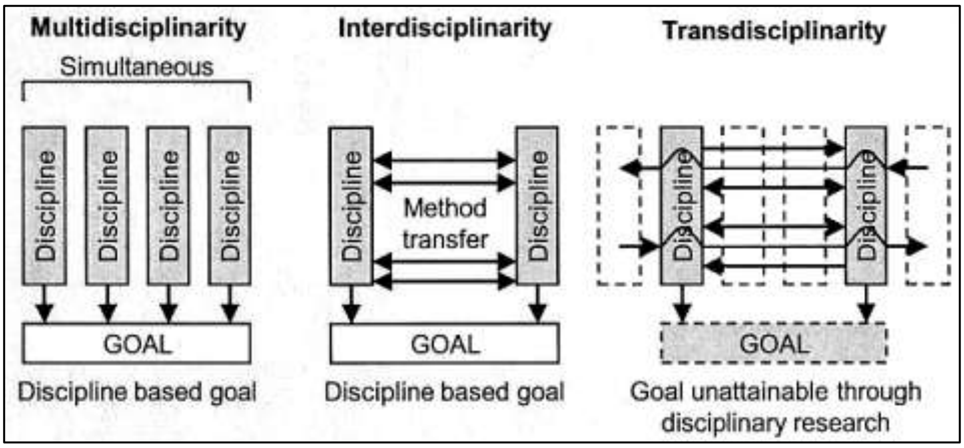

Figure 119. Cross disciplinary partnerships (Zoe Allman, DMU, 2009)

Recalling the structure of the Local Education Partnership (LEP), this public private partnership (PPP) was an experimental approach which has come to define the BSF programme. The “Regulator” was identified as Partnerships for Schools, a non-governmental quango set up to centrally administer and support local authorities entering the BSF programme. The “Producers” were identified as the private sector companies, responsible for the design, construction and operational management of the buildings. The “Client” was Leicester City Council (the Local Authority). And finally the “Customer” was seen to be the staff and students at the four schools.

How best to manage the LEP is a difficult question. As the analysis in this study has shown, there are numerous observations that corroborate the findings set out in the James Review (2011). Where transdisciplinarity comes into its own is when the goal, as stated above, is unattainable through disciplinary working. With regards to Leicester’s phase one schools, sustainability was not a goal that was clearly defined and set out from the outset. As a result, it became harder for all parties to focus on a “shared” vision of what a sustainable school should actually ‘do’ in practice.

To clarify, Nicolescu (1996) explains how transdisciplinarity operates simultaneously across, between and beyond disciplines. Similarly, Hirsch-Hadorn (2008) suggest this approach considers how methods can be shared and extended. Furthermore, Pohl and Hirsch-Hadorn (2007) recognise that transdisciplinarity crosses, manipulates and breaks boundaries where necessary.

More generally, as the RCUK[32] explains, multi-disciplinary research,

> *"... takes place at the edges of traditional disciplines and across traditional subject boundaries. The Research Councils believe that novel multi-disciplinary research is needed to solve many, if not all, of the next decade's major research challenges" (Source: Hugill, 2009)*

With this in mind, the researcher feels that an operational equivalent to the sustainable schools matrix could be developed where each and every stakeholder takes some form of contractual responsibility for each element [A1 to E3] of the matrix. As suggested earlier in the italics at the beginning of this chapter, shared responsibility can also be included where for example, building users must switch off lights and computers to save energy, supported by the FM provider to reduce energy consumption. This in turn may help to foster closer working relationships as the LEP works together to achieve sustainable outcomes across the 5 dimensions.

In this regard, the matrix acts as a schema upon which a new regulatory or contractual system can be devised. One which takes into account the true complexity of the system, and where responsibility is shared equitably based on clear and effective contracts. It has also been noted how inter-organizational "interactions" provide the professional networking which can promote innovation according to Hobday (1998, 2000) and Davies and Salter (2006).

In conclusion, it is the researcher's belief that sustainability can only be achieved through team work. Indeed, whilst the project considered the first 3 years of data, this only represents a small segment of time in relation to a building's predicted (30, 50 or 100 year) lifespan. However, based on the evidence collected to date, it would seem that School A consistently outperformed the other three projects all things considered (budget, comfort, energy, attainment etc).

More importantly however, a "sustainable" school should not simply be judged on outcomes alone. It is therefore crucial that we understand how each schools' individual circumstances (inputs) influence and determine the performance across the 5 "dimensions".

This linkage between inputs, processes and outcomes lies at the heart of a "systems" approach to research. On reflection, the BSF programme arrived at a time when Sustainable Development had yet to gain any real political traction. In the future, the researcher hopes that party-politics will take a back seat when seeking to rebuild and maintain the nation's estate of school buildings.

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[32] Research Councils UK

10.3 Sustainable Buildings

To address how buildings in general can become more sustainable in response to the challenges presented by Climate Change it has been interesting to read how some commentators from a practitioner's persuasion have explained,

> *"The pursuit of quantification obscures qualification. What about contexts and individual circumstances? What about design quality? What about perceived value? How best is the public interest served in the face of commercial self-interest? Where does duty of care to individual building users fit in, or indeed to the wider considerations of sustainable development?" (Leaman et al., 2010, p.4)*

This quotation captures many of the challenges which the present research has attempted to address. Shared contractual responsibility would be one such example that needs revision in order to avoid the complications which the "POE" literature has identified.

The research has also highlighted the inadequacy of current benchmarking tools when evaluating energy performance. Ideally, a national database is required so tailored benchmark targets can be assigned to specific projects based on pupil numbers, floor size, budget etc.

Furthermore, it is imperative that the commissioning ensures that sub-metering of services and zones are working prior to occupation. Reducing electricity consumption in modern buildings is a serious challenge. Evidence from across the literature tends to suggest that Air Handling Units (AHUs), Lighting and more recently ICT are the largest consumers of electricity. It is also imperative that BMS systems in larger buildings have zone controls that can switch on and switch off different parts of a building's heating system. South facing elements of a building for example should be expected to require less heating.

In conclusion, a report by the Specialist Engineering Alliance (SEA, 2009)[33], titled, *'Sustainable Buildings need integrated teams'* sets out a comprehensive review of necessary building reforms, identifying 22 recommendations which can now be viewed on the following page, all of which can and should be applied to future projects similar in scale and ambition to the BSF programme.

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[33] http://www.eclipseresearch.co.uk/download/construction_research_best_practice/sustainable_buildings_teams.pdf

Table 40. SEA Recommendations

List of recommendations

- Funding for public sector projects should, progressively, be made conditional upon evidence that the procurer has put in place an inclusive and integrated design team comprising those parties - consultants, project managers, engineering contractors, manufacturers and facilities managers - that are key to delivering sustainable outcomes. **(Recommendation 1, page 12)**
- Government must take a lead in adopting best practices in sustainability by commissioning integrated teams to provide facilities that demonstrate the step change in sustainable performance that such teams can deliver and that is urgently needed to drive forward innovation and deliver sustainability. Greater incentives and penalties should be introduced to ensure the improved ways of delivering sustainable facilities are driven through. **(Recommendation 2, page 12)**
- Central Government and Devolved Administrations should each appoint a high profile 'champion' to drive forward the integration and collaboration agenda. **(Recommendation 3, page 12)**
- Evidence of integration and collaborative working should be part of the best value review process in the public sector. **(Recommendation 4, page 12)**
- There is a need for a network to advise the public sector about assembling integrated construction project teams, and members of the Working Group are willing to come together to get this started. **(Recommendation 5, page 12)**
- Preference in public sector selection procedures should be given to firms that can - whether individually or through membership of reputable qualification schemes - demonstrate their technical proficiency, commitment to training and health & safety, and availability of adequate resources. **(Recommendation 6, page 14)**
- Public sector selection procedures should incorporate weightings that favour firms that have invested in sustainable and renewable technologies and that can show evidence of waste reduction within their businesses. **(Recommendation 7, page 14)**
- Integrated teams should manage cost collaboratively to ensure all members of the team are incentivised by efficiency gains. **(Recommendation 8, page 18)**
- Integrated teams should collaborate with their supply chains to pre-plan projects, raise efficiency and minimise waste. **(Recommendation 9, page 18)**
- Integrated teams should collect information about operating and maintenance costs and use this evidence as the basis of their assurances to clients about performance and cost in use of the facility. **(Recommendation 10, page 18)**
- Integrated teams must exploit the research and development capabilities of specialists to offer clients innovative and reliable solutions with enhanced long term performance that meet sustainability criteria. **(Recommendation 11, page 18)**
- The integrated team must stand by its products and provide training and support to ensure end users gain the maximum operational benefits and performance improvements from them. **(Recommendation 12, page 18)**
- Many larger projects would benefit from the setting up, during the early stages, of a Project Sustainability Working Group. Made up of specialists, this would provide advice on all aspects of sustainability to the client and others in the design team. The Integration & Sustainability Working Group of the SEA contains such expertise, and is prepared to form an advisory group or body that can offer consultancy services. **(Recommendation 13, page 21)**
- Greater flexibility in the treatment of capital and revenue budgets is required in the public sector, to encourage long-term thinking and capital investment in more sustainable facilities. **(Recommendation 14, page 23)**
- Clients should be clear about their overall budget and should entrust this to the integrated design team. Through its understanding of costs and performance, the team can make a value proposition that represents the optimum balance between capital and operating costs within the client's budget. **(Recommendation 15, page 23)**
- Consultants should, as a matter of course, use best practice advice, appropriate assessment tools, and government certification schemes. **(Recommendation 16, page 28)**
- Consultants should focus on ensuring operation and use are discussed at an appropriately early stage, set stringent targets in association with specialist members of the integrated team, and work with the supply team to ensure they are achieved in the completed project. **(Recommendation 17, page 28)**
- Consultants should develop better links to manufacturers and distributors, with common CDP seminars and courses. **(Recommendation 18, page 28)**
- Lead contractors should promote contact between designers and client, and between designers and specialist contractors and key manufacturers early in the process. **(Recommendation 19, page 30)**
- Lead contractors should ensure the whole integrated supply team is aware of specifications and targets, and must avoid substituting inferior products that jeopardise long term performance. **(Recommendation 20, page 30)**
- Integrated teams should explore project bank accounts and single project insurance both to reassure clients but also as a way of supporting integrated collaborative working. **(Recommendation 21, page 32)**
- Financiers who are investing for the longer term themselves need to take a long term perspective towards the facilities in which they are investing. **(Recommendation 22, page 32)**

sea

Specialist Engineering Alliance

10.4 Barriers and Limitations

With the benefit of hindsight, evaluating the old buildings using the BUS survey would have provided a more interesting comparative analysis. Similarly, had the BUS survey been carried out after the re-commissioning took place in autumn 2010, then the results may have shown a more positive picture in relation to environmental comfort. More generally, the limited response rate in terms of sample size undermined the quality and reliability of the Likert data.

As such, the researcher did suggest he might wish to spend a week in each school at the beginning of his PhD (2009-2010). Indeed, as Hesse-Biber (2010, p.16) explains,

> *"... the researcher should establish a reciprocal relationship with research participants..."*

He even completed a CRB application in the event that students would become directly involved. However, these non-specific engagement proposals were not seen to be a constructive way to proceed at this point in time (2009-2010).

From an energy perspective, the analysis of half-hourly electricity data would have been better if individual days, specifically Saturdays and Sundays were examined separately. It was also not possible to collect high resolution data for gas consumption, limiting the capacity to examine the efficiency of the heating systems. Future research may wish to include degree day analysis as and when the Trend online database has been properly commissioned.

From an educational perspective, the researcher was unable to collect statistical data about staff turnover and student detention/suspension/expulsion rates. This again would have helped develop a more detailed statistical picture of each school over the 10 year period.

Indeed, whilst the methodology did not delve deeply into one particular topic or another, the general approach to consider the wider "sustainable" picture gave rise to a framework that has captured the complexity and inter-connected nature of a school. In this regard, the researcher believes the analysis and overall findings have made an important and original contribution to knowledge.

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Appendix A: Policy and Regulation

Table 41. UK Policy Initiatives (2000-2010)

Policy imperative	What is it about?	What does it mean for sustainability?
Healthy Schools	The National Health Schools Programme was established in 1999 with four key themes: personal, social and health education; healthy eating; physical activity; and emotional health and well-being. These relate to both the school curriculum and the emotional and physical learning environment in school. Under each theme there are several criteria that schools need to fulfil in order to achieve national Health School status.	The key issues are that improving health of pupils helps to tackle social aspects of sustainability. The programme also has implications for new schools – especially for the space allowed for dining and physical activity. This may affect management of the grounds, bio-diversity, and/or energy use.
Every Child Matters (DfES, 2003c)	A new Government approach for all children to get the support they need to be healthy, safe and happy; to succeed in learning and to make a contribution to society, and to achieve economic well-being.	All groups providing services for children will need to work together the goals are specially alighted to the social and economic aspects of sustainability: health, social cohesion and strong economy. There are implications for building design due to the need for co-location services.
Five-year Strategy for Children and Learners (DfES, 2004a)	A strategy for education through to 2009. It seeks to break the line between lower social class and under achievement.	The drive for personalised learning, joined-up education and new services from schools will put more pressure on schools and their buildings. More space will be needed, and long opening hours. This strategy focuses on the social aspects of sustainability.
14–19 Education and Skills (DfES, 2005a)	A White Paper that sets out aims to transform secondary and post-secondary education so that all young people achieve and continue in learning until at least the age of 18.	There are implications for energy use in having larger buildings and more equipment, particularly ICT, being used by more people at any one time.
Extended Schools (DfES, 2005b)	By 2010 all schools will be required to offer a core set of extended services: childcare, parenting support and specialist services such as speech therapy or mental health services.	Longer opening hours are likely to increase resource use. Buildings will need extended heating and lighting into the evening, and schools may also need more space to accommodate the new services which needs to address social dimensions of sustainability.
Securing the Future (HM Government, 2005)	The UK Government's strategy for achieving sustainable development, published in 2005.	Defines the overarching goal of sustainability as enabling 'all people throughout the world to satisfy their basic needs and enjoy a better quality of life, without compromising the quality of life of future generations'. For schools, this means thinking about the global effects of their activities.
Sustainable Schools for Pupils, Communities and the Environment (DfES, 2006	The Sustainable Schools National Framework, published in 2006.	Describes a sustainable school as one that is committed to care: 'care for oneself, care for each other (across cultures, distances and time), care for the environment (hear and far)'. It defines eight 'doorways' for engaging with sustainability.
The Children's Plan (DCSF, 2007a)	The UK Government's 10 year strategy to 'make England the best place in the world for children and young people to grow up'. It sets out a series of ambitions for all areas of children's lives.	It sets out an unequivocal commitment to 'world-class buildings' and that all new schools will be zero carbon by 2016. £110 million will be allocated for sustainable buildings. New buildings will have space for co-located services and parents will have more involvement in school. Investing in safe areas to play at school will be a priority.

Source: Wilkinson (2008)

Table 42. UK Building Regulations

Regulation	What is it about?	What does it mean for sustainability?
BREEAM Schools	The Building Research Establishment's Environmental Assessment Method for school buildings is a point-based system that allows school to see how well designs for new or refurbished buildings are addressing sustainability.	Every newly built and refurbished school must achieve at least a 'Very Good rating, which means scoring points on management, health and well-being, energy use, transport, water, materials, land use and ecology, and pollution.
Part L of the Building Regulations on Energy Conservation	Mandatory minimum standards for new buildings and large refurbishments projects. These mean that all big building projects have to estimate CO_2 emissions from heating and power.	Every new building or large refurbishment for a school must be around 23% more efficient than equivalent buildings built before 2006. This is to reflect some of the requirements of the Energy Performance of Buildings Directive from the European Commission (January, 2006)
Building Bulletin 87 (BB87) Guidelines for Environmental Design in Schools	A technical manual published by the Department for Education and Skills (DfES). Covers energy use, ventilation, lighting and water services in schools.	This report sets a standard for energy use in schools, which for secondary schools is 5kgC per m² per year.
Building Bulletin 90 (BB90) Lighting Design of Schools	A technical manual published by the DfES which guides architects and engineers through the process of lighting desing in the context of the recommended construction standards for schools and the various types of spaces and activities found in schools.	The guide identifies the determining factors of good lighting design as architectural integration, task and activity lighting, visual amenity, cost, maintenance and energy efficiency. It describes the calculation methods and design tools that can be used at the early stages of a project and shows through theory and examples how to achieve synthesis between daylight and electric lighting. Tables of lamps and luminaires give an appreciation of the types of lighting available, their energy efficiency, colour rendering and other characteristics.
Building Bulletin 93 (BB93) Acoustic Design of Schools	A technical manual published by the DfES which outlines standards for noise entering the school, and for how easy it is to hear someone talking in a class.	The acoustic criteria can preclude natural ventilation for urban schools due to noise caused by open windows. It is recognised that the standards are set high. As a result it is accepted that some schools will not meet them all.
Building Bulletin 98 (BB98) Briefing Framework for Secondary School Projects (Revision of BB82)	Recommended area guidelines for new school buildings. Intended for use in briefing school design teams and explaining how much space will be needed for basic teaching, halls, learning resources, staff and administration, storage, dining and social space.	The new space standards, published in 2004, increase the minimum floor areas for primary schools by 17% and for secondary schools by 7% for teaching areas. These stipulations will mean more materials and land used in construction and may lead to higher energy consumption.

Source: Wilkinson (2008)

James Review: Letter to Michael Gove from Sebastian James

Sebastian James
The Capital Review
c/o 4th Floor
Department for Education
Sanctuary Buildings
Great Smith Street
Westminster
London
SW1P 3BT

Rt Hon Michael Gove MP
Secretary of State for Education
Department for Education
Sanctuary Buildings
Great Smith Street
Westminster
London
SW1P 3BT

7 April 2011

Dear Michael,

In July last year you asked me to lead an independent review into the way that capital is spent on schools in England. You wanted me to look at allocation and distribution of capital funds, at removing the burdens imposed by an accumulation of broken processes and at value for money of capital investment. You also told me that you wanted the review to be genuinely independent, above the political process and informed by the views of eminent figures in the field.

I am very pleased to now present you with my report. It has taken slightly longer than I anticipated, as I was very keen to test the emerging recommendations with as wide a group of interested parties as possible before putting them to you.

The work of the Review has been immeasurably assisted by the contributions of the Steering Group whose members have met regularly to challenge and comment on the work the Review Team has done. I would like here to record my thanks to them for their work – their collective experience and engagement has been inspiring. The able team assisting me at the Department have run several workshops involving over 100 people to gather evidence about how the current system works and what needs to change. I also issued a call for evidence which received just short of 500 replies from a wide range of parties interested in improving capital investment in education in the future.

In summary, I have found that the system of capital allocation and spending which has developed over at least the last decade has frequently resulted in poor use of resources, a bureaucratic system for providers and Local Authorities and a mixed – and at times poor - outcome for both parents and children. The schools building programme, Building Schools for the Future, has been one of epic proportions, at least in terms of the money deployed. However, because procurement has not been sufficiently centralised, and because the Government has not ensured that contracts are always negotiated by those who have the appropriate expertise, the public sector has failed consistently to get the value it should have done, given the commercial leverage that this scale of programme should command.

While the civil servants, local authorities and frontline professionals involved have done their best to administer the system they were asked to use, it is, in my view, the case that the system is not fit for purpose and has been working against them.

I believe that there are some very significant opportunities to increase the amount of schools regeneration that we can undertake for any given sum of money. To give you a flavour of this, the consensus view from our workshops was that as much as 30% of the total money spent could be saved and this is borne out by our initial pilot project in Doncaster.

By reforming the capital allocation system so that investment is focused on the condition of buildings and the provision of high quality school places, and by creating a robust and fair local process for prioritisation of projects, funding can get to where it is needed most. Through a more standardised approach to design and an expert, centralised approach to the procurement and delivery of major projects, greater quality and value for money can be achieved. Sharper accountabilities for maintaining buildings and better procurement routes for doing so will help ensure that the current estate is able to deliver for our children in the decades ahead.

My vision is of a system which prioritises both quality and value, which makes the best use of professional expertise to ensure that, even at a time of significantly reduced budgets, we achieve your aim of providing fit-for-purpose facilities and securing additional places where they are needed and helping the disadvantaged.

Putting my recommendations into practice will be a major challenge. I know that I am asking for a significant change in culture and practice. Getting the right structures in place to deliver at national and local level will be vital. I anticipate that, for some stakeholders in the process, there will be parts of my suggested approach that may be less palatable than others and that there will need to be some give-and-take. However, the team has been heartened by the high level of consensus that has been building among the many different parties that have been involved in this process, and I believe we all need to remain focused on the goal of delivering the educational infrastructure that we need at a cost that we can afford.

I am very grateful for the support Tim Byles and his team at Partnerships for Schools, as well as civil servants in the Department, have given to my review.

With Kind Regards

Sebastian James

Table 43. RIBA and Soft Landings Frameworks (2008)

RIBA Plan of Work 2008				Soft Landings		OGC Gateways (at end of stage) and milestones in the RIBA *Plan of Work*
Stage letter and name			*Main activities*	*Principal additions*	*Supporting activities*	
Preparation	A	Appraisal	Identify client needs. Do feasibility studies		Define roles and responsibilities	1. Business justification
	B	Design brief	Develop an initial statement of requirements and procurement methods	**Stage 1. Briefing:** Identify all actions needed to support the procurement	Explain Soft Landings to all participants. Identify processes and sign-off gateways	2. Procurement strategy
Design	C	Concept	Implement and expand the brief. Prepare the concept design. Review the procurement route	**Stage 2. Design development:** to support the design as it evolves	Review past experience Agree performance metrics Agree design targets	3A: Design brief and concept approval
	D	Design development	Develop concept design. Update outline specification and costs. Complete project brief		Review design targets Review usability and manageability	Apply for detailed planning permission
	E	Technical design	Prepare technical design and specification sufficient for coordination and information for statutory standards		Review against design targets. Involve the future building managers	3B: Detailed design approval
Pre-construction	F	Production information	Prepare detailed information for construction. Review information provided by specialists		Review against design targets. Involve the future building managers	Apply for statutory approvals
	G	Tender documentation	Prepare or collate tender information		Include additional requirements related to Soft Landings procedures	
	H	Tender action	Identify and evaluate potential contractors and/or specialists. Submit recommendations to client		Include evaluation of tender responses to Soft Landings requirements	3C. Investment decision
Construction	J	Mobilisation	Let the contract. Issue information to the contractor. Arrange site handover to the contractor		Confirm roles and responsibilities of all parties in relation to Soft Landings requirements	
	K	Construction to practical completion	Administer the contract. Provide further information as required. Review information provided	**Stage 3. Pre-handover:** Prepare for building readiness. Provide technical guidance	Include FM staff and/or contractors in reviews. Demonstrate control interfaces. Liaise with move-in plans	4. Readiness for service Practical completion
Use	L	Post-practical completion	L1 Administer the contract after practical completion and make final inspections		Incorporate and Soft Landings requirements	Final account
			L2 Assist building users during the initial occupation period	**Stage 4. Aftercare in the initial period:** Support in the first few weeks of occupation	Set up home for resident on site attendance	
			L3 Review of building performance in use	**Stage 5. Years 1 to 3 Aftercare:** Monitoring, review, fine-tuning and feedback	Operate review processes. Organise independent post-occupancy evaluations	5. Benefits evaluation

Appendix B: Miscellaneous

Extracts taken from LCC Documents which relate to energy and procurement:

Leicester
City Council

WARDS AFFECTED
All Wards

FORWARD TIMETABLE OF CONSULTATION AND MEETINGS:

Leadership Management Team
Lead Member Briefing
Climate Change Board
Environmental Partnership Board
TLE Portfolio Board

Environmental Standards in the Building Schools for the Future (BSF) Programme

Report of the Director of Learning Environment

1. Purpose of Report

1.1 The purpose of this report is to advise the Cabinet Lead for Children's Services and the Climate Change Board and the Environmental Board Partnership Board of:

The environmental standards achieved in BSF Phase 1; the approach to securing the highest affordable environmental standard in future phases; the anticipated standards to be achieved in the next phase [redacted] School) and the partnership arrangements that have been established with De Montfort University Institute of Energy and Sustainable Development. The report also considers the definition of carbon Zero and corporate sustainability targets.

2. Summary

2.1 The environmental performance in Phase 1 of BSF significantly exceeds the required standards that were originally proposed in the Strategic Business Case (SBC).

2.2 The TLE Division has developed a successful partnership approach with the LEP, the supply chain and DMU to optimise investment in carbon reduction and secure the highest affordable levels of sustainability. This report set outs the approach of completing option appraisals for reduction in carbon emissions for each capital project and also concurrently submitting bids for additional sustainability funding. This will enable the highest standards to be achieved in relation to the technology and funding available and the time each project is constructed. This approach is working towards the One Leicester commitment for Reducing Carbon Emissions.

The TLE Division is also working through an organizational review to ensure a sustainable approach to staffing of the 'clientside'. In particular this review aims to reduce reliance on consultants and agency staff and ensure maximum return of BSF investment through additional environmentally sustainable facilities, features and practices.

2.3 The environmental standards for Phase 2 schools will further build and improve upon the standards achieved for Phase 1.

2.4 The TLE Division has established a partnership with the Institute of Energy and Sustainable Development at De Montfort University and a number of collaborative projects are being undertaken around the BSF Programme which are adding further value to the sustainability standards of the programme.

2.5 The experience of the BSF Programme to date is being used as a yardstick to reflect upon the Council's current strategy and targets for sustainable schools.

3. Recommendations

3.1 The Cabinet Lead Member for Children's Services and the Climate Change Board and Environmental Partnership Board are recommended to note the report.

4. Report

The environmental standards achieved in BSF Phase 1

4.1 [redacted]

4.2 The environmental standards specified for BSF Phase 1 were the national standards prevailing at the time. These were BREEAM excellent for new schools and BREEAM very good for refurbished schools, Carbon Emission limits set by Part L2 of the Building Regulations 2006 and a local Planning requirement/Strategic Business Case Submission that at least 10% of energy should be from renewable sources.

4.3 All schools in Phase 1 achieved the specified standards. Notably, the new build schools were designed to achieve Carbon Dioxide emission levels with a 42% improvement over Building regulation requirements. Across Phase 1, renewable energy will be 24% of the total compared with the 10% requirement. This was a considerable achievement considering the limited opportunity to work in partnership with the supply chain during what was a competitive process to procure these schools.

4.4 It should be noted that G4S is the Council's BSF Facilities Management (FM) partner and eventually they will be responsible for the facilities management of most of the City's secondary schools. This company and all of its sub-contactors are accredited to the Environmental Management Standard ISO 14001. G4S will seek individual accreditation to the standard for every school whose facilities it manages.

Bidding process was seen to obstruct the sustainability concerns ..

The approach to securing the highest affordable environmental standard in future phases

4.5 Whilst the designs for Phase 1 schools were developed in a competitive environment, with limited opportunities for partnership working with the supply chain, the approach to securing the highest standards of environmental performance is based on a partnership with the Local Education Partnership (LEP) ([redacted] LMEC). It is acknowledged that higher standards may require additional capital investment and this might be recovered through savings in running costs. The approach has been to set three levels for performance targets. The starting point or the baseline standard will be affordable within the standard BSF allowances; higher standards may require more capital.

4.6 **The base standard** comprises a standard to BREEAM 08 'Excellent' for new schools and 'Very Good' for refurbished schools. In addition, it requires planning requirements to be achieved for each individual school rather than across a phase with building regulation requirements as Phase 1.

The intermediate standard is as the minimum standard but with the energy consumption of each school being reduced to 60% of the 2006 Building Regulations requirement.

The highest standard is as the minimum standard but with the energy consumption of each school being reduced by up to 100%.

The LEP has a contractual requirement to meet the base standards and must also investigate and evaluate options to enhance sustainability and advise of the cost of raising performance to a higher level.

4.7 The government has also recognised the need to increase capital investment to raise sustainability standards and offers local authorities additional funding of £50 / sq.m, in 3 schools, to enhance environmental performance. This is known as the Carbon Calculator funding and is likely to add £1-1.5m to the BSF funding envelope overall.

[redacted]

Before commencing Phase 2, the TLE Division commissioned consultants Faithfull and Gould to assess three recently completed new schools. They were asked to assess the potential means by which the environmental performance of these schools could have been improved to achieve a 60% carbon reduction and also be carbon neutral in operation and to advise how much this would have cost. The consultants concluded that the 60 % reduction would have been achievable at a reasonable additional cost (typically 8% increase on a primary school and 4% on a secondary school for new build schools. In relation to refurbishment around 50% reduction of carbon emission could be achieved, typically around 8 to 10 for refurbished schools) but carbon neutral would not be achievable in practice.

4.8 During the early stages of the development of designs for Stage 2, the Department was successful in securing a further grant of £1m from DCSF Zero Carbon Exemplar projects programme. The school selected for the bid was Rushey Mead School, since this school's situation and geographic location provided maximum opportunity for a successful bid and the timing of expenditure would align with DCSF requirements. The bid was based on achieving a 50% reduction on carbon emissions compared to the existing school and demonstrating a full range of renewable technologies in the project.

4.9 The approach that the TLE staff took to optimising environmental performance has resulted in a number of tangible benefits. In the case of Rushey Mead School, the LEP provided a detailed report, setting out all the available options with costs, energy savings and carbon emission savings. In effect, this was a 'shopping list' which was prioritized in order of return on investment. Some of the options will be included in the project without exceeding the existing funding envelope (bearing in mind that this has already been expanded with the additional £1m), some options to enhance the project would require prudential borrowing and these are currently being investigated. It is expected that the target of a 60% reduction in existing carbon emissions will be achieved within existing funding and this may rise slightly with further enhancements funded through prudential borrowing.

4.10 In the case of [redacted] a combination of the sustainability targets, and the cost of a protracted construction period required to carry out a phased refurbishment while the school remains open has led the LEP to propose a new build solution for the school within the funding envelope allocated for a refurbishment.

4.11 In relation to the existing furniture and equipment in schools, a standard process is adopted that as much equipment as possible is transferred to the new school, the remainder is firstly offered to other schools in Leicester and if not required then shipped to Africa.

Repair, Re-use, Recycle ....

Partnership arrangements with De Montfort University

2 The TLE Division has forged a strong working partnership with the Institute of Sustainable Development and Energy at De Montfort University. There are three main strands to this work:

(a) The Department and DMU jointly have secured funding from the Department for Business, Innovation and Skills (BIS) for a research project to engage schools in 'Understanding the Science of Low Carbon Technology'. A post-doctoral researcher is working with students and staff and the BSF team to help students and staff understand and take ownership of sustainability issues and enable them to influence school designs. This is a three year project with funding worth around £300,000.

(b) A knowledge Transfer Partnership (KTP) between the Council and DMU is funding a researcher to work with the BSF Team and also the Primary Capital Programme Team to drive the reduction of carbon emissions through the design of new schools. The KTP will support the implementation of the leading edge technology in schools that is currently being developed by the Institute of Energy and Sustainable Development at DMU. This programme is also funded by BIS and is worth £90,000 over a 3 year period. The post-

Annex A

Leicester
City Council

WARDS AFFECTED
All Wards

FORWARD TIMETABLE OF CONSULTATION AND MEETINGS:

BSF Sustainability Scrutiny Task Group

Initial Discussion Paper – Review of BSF Phase 1 and Future Opportunities

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Report of the Head of Planning and Property, Children and Young People's Services

1. Purpose of the Report

1.1.1 The purpose of this report is to review the Departments approach on sustainability, answer questions raised by the task group on BSF Phase 1 Schools, review the sustainable features for this phase and the options on future phases. The report then outlines the areas for discussion and opportunities for the task group to input into policy development for the next phases of BSF. Although the focus of the task group will be BSF there will be some overlap on primary schools with the forthcoming Primary Capital Programme and possible Council wide strategies for sustainability.

2. Summary

2.1 Review of BSF Phase 1 Schools

2.1.1 There are four schools in Phase 1. Two of the schools are new build, under a Private Finance Initiative (PFI) form of contract, one school is a new build under a design and build (D&B) contract and one school is being refurbished also under a D&B contract. All four contracts require the Local Education Partnership (LEP) to comply with the current legislation at the time of the contracts being tendered. The main areas of legislation being the Building Regulations Part L2 and the Planning (BE16) condition at the time to achieve 10% on site renewable energy. Currently the LEP has achieved a higher percentage of 24% on site renewable energy, which is a good achievement considering this was secured in competitive tender. This figure has been achieved across the combined 4 schools energy usage. The main focus of the [redacted]

2.1.2 The new PFI schools will also have:

- Materials sourced from the Building Research Establishment (BRE) Green Guide
- Energy efficient lighting
- Maximum use of natural ventilation
- 'Excellent Building Research Establishment Environmental Assessment Method (BREEAM)Rating
- Intelligent metering
- CO2 emissions reduced further than current Building Regulation requirements (by 42%)
- Water efficient sanitary ware and leakage detection systems

The new D&B School will also have:

- All the features noted above except boilers that will be energy efficient gas-fired boilers

The remodelled / refurbished will also have:

- All the features noted above except BREEAM Rating of 'Very Good'

Whilst it is important to note that current sustainable achievements could be improved upon, we should dispel the idea that Phase 1 sets a precedent or benchmark for later phases.

There are two very clear reasons for this; firstly, the process for the design of the first four schools was governed by the strict rules of competition, since the quality of the designs formed part of the tender evaluation. This limited engagement with contractors and prevented the Council leading the contractor towards any particular solutions.

Secondly, the nature of the contracts for PFI and facilities management (FM) was complex and followed the standard models prepared by Partnerships For Schools. It was difficult during the procurement process to introduce variations to these contracts, which would have elongated the process to Financial Close.

2.1.3 Additional funding from the Council and External Sources

Due to the complex nature of commercial negotiations, it has not been possible to supplement [redacted] proposals with further Council sponsored initiatives and [redacted] on of wind turbines have been carved out of the BSF contracts.

As part of the CYPS Capital Programme in 2007/08, £60,000 of match funding was earmarked for further sustainability initiatives in the Phase 1 BSF schools. Following feasibility studies, it was proposed to install a 50kw wind [redacted] for a turbine at [redacted] The remainder of the funding is to be raised from [redacted] School and prudential borrowing. However, on [redacted] we are currently waiting to find out whether we have managed to secure third party funding from another source.

2.1.4 Teaching and Learning

It is important that we take the opportunity of providing educational tools in order that children and teachers are engaged in sustainability on the BSF programme. This leads into curriculum opportunities, which enables schools and communities to learn about energy usage, technologies and climate change. All schools will therefore have service metering that will be linked to a remote energy management system and data will be collected and made available via an IT solution for use in the schools. Schools will also have prominent high – visibility metering in the school foyer. At [redacted] there will be a virtual Energy Centre that links into the metering for the biomass boilers, the wind turbine and a variety of other small educational micro generation examples such as photovoltaic cells.

The engagement of pupils during the construction period is being developed through partnership working with the LEP, Millers Construction, CYPS and Groundworks UK. It is envisaged that this will be a continuation of the work being already carried out through the EMAS programme and further development of the school curriculum in relation to climate change and renewable technologies being installed on BSF Phase 1.

2.2 Questions BSF Phase 1- these are questions that have been raised by the Environmental and Sustainability Task Group

2.2.1 Do we understand why sustainability came only 19th in order of priorities by the schools as outlined in the Outline Business Case? This goes against sustainability being the second priority within education section of the Corporate Plan of the time (2003-2006)?

We are still investigating the response to this question.

2.2.2 Have eco-champions / council members been appointed from within the staff and pupil bodies?

The process for the design of the first four schools was governed by the strict rules of competition, since the quality of the designs formed part of the tender evaluation. This limited engagement with contractors and prevented the Council leading the contractor towards any particular solutions. For these reasons we have not to date nominated eco-champions from the Council or the Schools at this time.

2.2.3 What workshops/forums were conducted during design phase and who did they involve?

MF Associates arranged two workshops at each school, which involved such parties as School Councils, teachers, Groundworks UK and the two preferred bidders. Engagement activities were arranged for pupils, teachers and

governors to understand the science, engineering and mathematics of the design and operation of low-energy school buildings. This included visits to a low energy building (the Queens Building at De Montfort University); discussion with teachers and governors; and pupils, teachers and governors debating with "policy makers" and the potential designers of their new school buildings. This created a sustainable vision for each school. Unfortunately due to the limitations on funding the school's visions have not been fully achieved. Further workshops with the schools and other parties are planned in the summer to compare the requirements within their original visions against the Phase 1 school designs. MF Associates also arranged interviews with the head teachers on Phase 1 schools.

2.2.4 What negotiations were held with [redacted] on maximising sustainability elements of the buildings? Alternatively how were sustainability elements handled within the tender documents?

Several meetings at pre-contract stage were held with [redacted] where they clarified the environmental features being provided on the Phase 1 schools (please refer to paragraph 2.1.2). Currently the LEP has achieved a higher percentage on site renewable energy compared to the requirements of the tender documents (please refer to paragraph 2.1.1 and 3.1.1).

[redacted] were asked to assess the opportunities to improve the sustainability of Phase 1, but this was not possible due to the limitations of the funding and the other school priorities.

2.2.5 What other forms of funding were considered to try and draw into phase 1? If none, why not?

Please refer to paragraph 2.1.3 concerning the wind turbine proposals for Phase 1.

CYPS commissioned feasibility studies in spring of 2007 to establish what sites were suited to renewable technologies.

All sites were suited to photovoltaic cells. Due to the long pay back periods which could be up to 120 years, it was considered that photovoltaic cells would not be financial viable even when taking into account a 50% grant from a third party source.

2.2.6 What negotiations with schools for putting up some of their own money given the anticipated reduced energy costs on an on-going basis?

Please refer to Paragraph 2.1.3 and 2.2.5.

2.2.7 What plans for staff to be 'energy managers' – that is to make the most of the buildings environmental assets?

No specific members of staff in the four schools are named as the energy managers. However all schools on Phase 1 will have intelligent monitoring of services and are in the EMAS programme, which will involve personnel from Groundworks, teachers, pupils, premises officers and the Council Energy

Office. Without knowing the full details of the energy manager's job role it is difficult to comment, but it is anticipated that the personnel mentioned above would cover the majority if not all of the duties.

2.2.8 *What discussion has there been re: curriculum advisors and spending an amount of learning time looking at specific sustainability elements of the new buildings?*

Please refer to 2.2.3. Please also note that this has been and will be continued to be delivered through the EMAS Programme by Groundworks please refer to 2.1.4.

2.3 Opportunities for later BSF Phases

2.3.1 Technology

It is anticipated that the range of technologies used in Phase 1 will be expanded.

Importantly, since the next phases will be developed in partnership rather than in a competitive environment, the Council will be able to decide where the balance between cost and benefit lies rather than relying on the contractor to decide which technologies are appropriate. Technologies that could be considered in the next phase include:

- Photovoltaic cells
- Ground source heat pumps
- Green roofs
- Sustainable urban drainage
- Rainwater harvesting
- Wind turbines
- Solar hot water systems

2.3.2 Capital Investment

We need to re-examine the facilities management contracts to make it an attractive proposition for the facilities management contractor to invest capital funds and recoup the expenditure from reduced energy costs. We also need to maximise funding opportunities through prudential borrowing up to the maximum period of 25 years.

The Government now accept that in order to reduce whole life costs it is necessary to increase initial capital investment. DCSF has announced that some new build BSF schools will receive an additional capital allocation of £50/ sq.m to improve sustainability. Early indications are that three schools will receive this additional funding (amounting to about £500,000 per school) but this will depend on future decisions about phasing and whether schools are refurbished or rebuilt.

The continuation of the submission of bids for sustainable technologies referred to in 2.3.1 from third party sources needs to continue to maximise the funding available.

2.3.3 Engaging with young people and the school curriculum

The task group has a role to play in determining the policy and approach to making schools more sustainable. The terms of reference for the task group include an extract from the Partnerships for Schools Guidance on preparing a Strategy for Change and the specific questions that require a response as part of the strategy. Either by including students on the task group or by setting up a separate student reference group, it should be possible to give young people a greater say in determining the approach to sustainable schools.

Since the next phase of schools will be developed in partnership rather than in a competitive environment it should be possible to allow students much greater involvement in the design process, for example, through participation in design workshops.

Groundworks UK are environmental experts and specialise in this field of school engagement and providing information for the school curriculum on climate change through their work with schools on the EMAS programme. They could carry out this role on behalf of the CYPS on the future phases of BSF. Please also refer to the separate report on prepared by Groundworks UK for the task group, which details their proposals' titled 'Education for Sustainable Development'. — Groundworks Google.

It should also be noted that MF Associates ran workshops on the Phase 1 schools and could continue this work on future Phases.

2.4 Areas for Discussions

2.4.1 Below are a number of options and points that the task groups need to discuss, consider and agree how they are progressed:

a) The definition of a carbon neutral school. The DCSF have stated their definition to be 60% on site renewable technologies and the remainder being off set. Should the task group be considering 100% renewables? This target would be extremely difficult to achieve and may not be possible on all school sites. Should it also be assumed that we are only negating the energy used by a school over each year of its life cycle and we are excluding the carbon generated through transportation to school and procurement resources such as food? A further option is a stepped approach where we start at 60% and then progress higher in an agreed time frame may be linked to the BSF programme phases.

b) We understand there are no current examples of a carbon neutral school and the Council does not have the expertise to establish the cost of creating a carbon neutral school. Officers have recently met Faithful and Gould a Construction Consultant who have acted as advisors for the DCSF on carbon reduction on schools. It is proposed that Faithful and Gould or a similar consultant could be commissioned to provide this information but the scope needs to be determined, suggestions for which are listed below:

i) To carry out two studies of a new build school currently being constructed on Phase 1, (possibly [redacted] School) to determine the capital cost and the technologies required to covert this school to carbon neutral. The first study would assess the cost with 60% renewable technologies (DCSF definition) and the second survey at 100% renewable technologies

ii) To complete the same studies on a refurbished school on Phase 1. We would suggest this would be Fullhurst Community College.

iii) To complete the same studies on a new build primary school.

c) Due to the majority of carbon emissions being generated by the existing primary school building stock, a study could be carried out by Faithful and Gould on a number of different size and types of buildings, where minor, major or new future maintenance work is planned. This study could estimate the funding required to achieve the schools environmental targets on carbon reduction and provide information for the Primary Capital Strategy.

d) Should this be rolled out across the remaining CYPS buildings and also other department's buildings to create an overall Council strategy for carbon reduction to meet the Council targets? This decision would probably fall outside of the remit of this task group.

e) It should also be noted that the Council will incur taxation of around £12 per metric tonne of carbon per year starting in around 2010. It is unclear whether this is limited to energy use or will be wider reaching (such as people travelling to work, purchasing materials, food etc.) and it is also uncertain whether schools will be included at this stage. It is important that the Council should be in a position to know its actual emissions in order for the correct tax to be levied. Currently, the Energy Office can provide this information on energy usage only, through intelligent monitoring. – But BMS systems don't work.

f) How BREEAM should be used as part of the Council environmental targets?

2.4.2 Other environmental programmes are being carried out across the Council and by other organisations such as Groundworks UK. These current programmes and the future carbon reduction strategies and programmes by the Council should all be linked and co-ordinated. One suggestion is that an Environmental Project Board could be set up which includes Councillors and Senior Officers for each department to co-ordinate the Councils environmental strategies and programmes. Under this board an Environmental Working Party could be formed, co-ordinated by the existing Environmental Team. This team includes project managers from all department involved in sustainability to ensure awareness and cross fertilisation of strategies and programmes.

Some of the environmental projects, which are now being carried out are listed below:

g) Within the CYPS Capital Programme 2007/08 £1m of funding was allocated to undertake educational and environmental capital projects to schools buildings. The programme is split into two sections, the first section relates to quick win schemes such as the replacement of light fittings and the second section relates to micro-generation renewable projects such as wind turbines and photovoltaic cells. Further funding is being secured to increase the size of the programme from Schools Devolved Capital, prudential borrowing and the Low Carbon Building Programme Phase 2 (LCBP 2). The LCBP is government funding, where Public Sector organisations can claim up to £1m of grants for various micro technologies. The grants on offer range from 30% to 50% of the capital cost of each project.

h) A feasibility study is currently underway to assess the possibility of converting 4500 tonnes of timber waste material from City Landscapes to fuel the biomass boilers at [redacted] There could be government grants available to fund the feasibility. Further funding from DEFRA may be available for biomass boilers.

i) A proposal from Groundworks UK is currently being considered by the CYPS Directorate for an ambitious project to install wind turbines on approximately twenty schools sites to generate a total of two megawatts of green energy. The funding for the scheme could be raised from a community share issue and matched with a bank loan, which will hopefully raise the capital to install all the wind turbines. The bank loan and the shareholders would be re-paid through the school purchasing the energy and/or from selling the energy back to the grid.

j) The Adult and Housing Department's feasibility study into large-scale wind turbines in Leicester, please refer to paper presented to Cabinet Briefing on 15 October 2007.

k) The Regeneration and Culture Department's programme to plant 10,000 trees in the City.

l) The visionary idea from Alan Gledhill (Project Manager Leicester Better Buildings Project) of the Council being facilitator for making schools Energy Centres, which generate energy from renewable sources for use by the school and the local community.

3.0 Conclusion

3.1.1 The schools that are being constructed in Phase 1 of the BSF programme are significantly exceeding the Building Regulations requirements and Planning conditions in relation to carbon emissions that were set at the time that the first phase was tendered in 2005. Further improvements in reducing carbon [redacted]

further sustainable features but the limitations of funding and the other priorities did not make this possible.
At the time that the projects were tendered the Council did not have in place a formal policy on sustainable buildings, which is now in place through the Climate Change Action Plan (March 2007). The aspirations of the Council on climate change have move significantly forward compared to the Council position when the BSF project was tendered in 2005.

Significant

3.1.2 The Leader of the Council made a speech at a recent environmental conference in Leicester and stated the following:
'We are aiming for our new schools to far exceed current CO_2 emissions requirements and raise awareness in the wider community of environmental technology and issues.'
'Schools can be made into places where communities learn about sustainability by making their school building tools for teaching and learning.'
'We welcome the fact that Government have set an ambition for all new school buildings to be zero carbon by 2016, but there should be sufficient funding for schools to exceed, not just meet targets'.

3.1.3 We would welcome carbon neutral studies to be carried out to establish the technologies required and their respective costs, with linkages to the Council targets for reducing emissions. This would put CYPS in a strong position where we know the size of the task; the costs involved and is assist in lobbying and hopefully securing further funding to make Carbon Neutral schools possible.

3.1.4 There are significant opportunities with the remainder of the BSF Programme to secure additional funding for green technology, to engage with young people in the design of their schools and to make schools places where young people can learn about and discuss sustainability issues by experiencing what happens in their own environment.

reviewed the sustainable features for this phase and the options on future phases.

The Capital Programmes Manager introduced the report. He stated that the phase 1 work comprised four schools, and that two of these were to be built under a Private Finance Initiative (PFI) form of contract. These two schools were to have Co_2 emissions reduced further than current Building Regulation requirements (by 42%).

In relation to the opportunities for later phases it was made clear by officers that the range of technological methods used during phase 1 would be expanded. It was generally expected that the aim of phase 2 would be to ensure a higher level of criteria would be used, and for the buildings to be constructed with a better standard of thermal insulation which in turn would minimise heating costs.

A further opportunity identified for future phases was to conduct better pupil engagement with the projects. It was stated that displays of the work were put together in those schools within Phase 1, but that efforts could be made to set-up more physical ways for pupils to engage with the adaptations to schools, and that it was possible that this could still be achieved within phase 1. In addition, Members heard that a Building Schools for the Future Website would be made created for use by pupils within schools.

In relation to alternative funding sources, the Task Group recommended that efforts should be made to try to acquire more third-party funding.

It was reported that government had set a target of achieving zero Carbon admissions in all new build schools by 2016. The City Council, as part of it's One Leicester visionary document had set to achieve the same target by 2013. It was thought however, that this earlier date would present an opportunity to review the target.

16. DEFINING AND ACHIEVEING 'ZERO CARBON' - THE IMPLICATIONS FOR NEW BUILDINGS

A further paper was circulated to the Task Group that attempted to explain what was meant by 'Zero Carbon', whether or not it was possible to achieve 'Zero Carbon', the key target dates and the main barriers.

Mark Jeffcote, Senior Environmental Consultant, stated that a definition of 'zero carbon' had been established for houses through the Code for Sustainable Homes and that the definition could also be applied to non-domestic buildings if some minor alterations were made. He further stated that the definition did not include the total carbon footprint of constructing a new building.

Mark referred again to the 'One Leicester' strategy and Members sought clarification of whether the target for achieving 'Zero Carbon' in the City was 2013 or 2016. It was agreed that a response to this query be provided by Keith Murdoch, Director of Partnerships.

Media Articles and Documents:

Council Website

Council News

Home > News

[redacted] out of 'Special Measures' in record time

22/07/2010

[redacted] has come out of 'Special Measures' in an extraordinary 15 months.

Ofsted has carried out a number of monitoring visits since the school was deemed to be failing, and today they have published a report, which praises the remarkable team effort displayed by this school and gives an overall judgement of 'Satisfactory'.

Overall the report identified a number of improvements including the fact that [redacted] is an inclusive school because 'students are well supported both inside and outside the classroom', 'students collaborate well in pairs and small groups and are willing to help others when they encounter difficulties' and
'the school's provision is often effective in helping students whose circumstances make them vulnerable with their personal and social development'.

They also rated the effectiveness of leadership and management as Good.

David Kershaw, the Executive Principal and Rosie Kemp, Acting Principal were both singled out for praise by the Inspectors who said they provided effective leadership and have 'moved the school forward well, often in the face of very difficult circumstances'.

Councillor Vi Dempster, Deputy Leader and Cabinet Lead for Children and Schools, agreed. She said: "I am absolutely delighted that the hard work that David and Rosie have put into [redacted] t has been recognised. They have epitomised partnership working, not only by the way they have worked together but also by the commitment they have shown to the School and the Independent Executive Board established by the Council. The improvement in life chances for the students at this school is remarkable."

David Kershaw responded by saying: "First of all this is a tremendous achievement for the whole school and we only got there by a remarkable team effort. At Easter 2009 the school was pretty demoralised and in just 15 months the school has become a positive, optimistic environment which I know has a great future."

The Inspectors noted that considerable attention has been given to raising students' aspirations by a policy of early entry for GCSE examinations in English, Mathematics and Science, with many results already successfully 'banked'.

The report goes on to say that 'an increasing proportion of students are successful in gaining the grades they need to follow their ambitions for higher education or employment'.

Rachel Dickinson, Strategic Director for Children at Leicester City Council, said: "It is really pleasing to see so many more students taking their GCSE exams, let alone the fantastic results that the school is already seeing. The commitment to improvement of everyone at the school, leaders, teachers and students alike, is paying dividends. The results certainly speak for themselves."

It also notes that there has been a dramatic reduction in the use of exclusions to manage challenging behaviour and praises the behaviour support unit for its marked impact on behavioural and emotional difficulties.

Amongst the report's recommendations for improvement were: 'making more effective use of learning objectives that focus on students' progress individual lessons'
and 'ensuring that planning meets the needs of all groups of students, including those who are the most able'.

Also, whilst acknowledging the effectiveness of the leadership team the report stated that it could be improved even further by: 'maintaining and developing the system for tracking and supporting the work of students to accelerate their progress and raise attainment' and 'ensuring that all heads of subjects play an effective role in improving teaching and learning within their departments'.

Patrick Scott, Chair of the Interim Executive Board, which governs [redacted], acknowledged the areas for improvement by stating: "We are absolutely delighted that the Inspectors have recognised how far the school has come and the commitment and dedication of its staff and students. We have a full programme of improvement which the senior management team is systematically embedding throughout the school".

The full report can be found on www.ofsted.gov.uk

Leicester Mercury

Local Newspaper

School fund to buy uniforms

By **Leicester Mercury** | Posted: June 25, 2011

Comments (0)

A city school says its strict uniform policy is having a positive effect on behaviour and learning but some parents are struggling to pay for them.

Now, [redacted], in Braunstone, is looking to introduce a fund to help families kit out their children.

The fund would also be used to pay for PE kit and school trips.

Tom Campbell, who has been headteacher at the school since September, said: "We realise there's a cost price to families where there might be more than one child who needs a uniform, and trip to be paid for, that's why this fund aims to help.

"We're aware of our community's needs and demands on househo income are getting bigger. We want to make sure all our students have every chance to be and do their best because going on a school trip could mean the difference between a GCSE grade."

The school has successfully applied for £1,250 from the Westcotes £15,000 community fund and is bidding for the same amount from the Braunstone and Rowley Fields and Western Park community funds.

The school introduced a traditional-style school uniform code, including blazer, 18 months ago and says it was part of its bid to raise standards.

Mr Campbell said: "We've found the uniform has really made a difference. It's been one of the significant factors in making sure pupils have the right hat on for school.

"We want to make sure they arrive with the frame of mind that there are standards to adhere to and that includes behaviour.

"We've found the blazers and ties give them the right mindset and that's had a knock-on effect with their results."

The uniform has been welcomed by students.

One said: "I think it looks smart and as everyone wears the same no-one gets picked on for what they wear."

Another said: "People who see us dressed smartly know we go to a good school."

[redacted] was in special measures this time last year but it has since come out.

Last summer, it recorded the biggest improvement in GCSE exam results in the city, with 38 per cent of pupils achieving five A* to C grades including English and maths – a leap of 19 per cent on the year before.

The school eventually hopes to sustain the school fund with fund-raising events and possibly develop a swap shop where parents can buy or sell second-hand good-quality uniforms.

Westcotes councillor Sarah Russell said she was delighted the ward community fund could help.

She said: "There's been a shift in the school culture at Fullhurst and the uniform is helping to create the right mindset to being in school, getting good results and behaving.

theguardian

[redacted]

National Newspaper

Where the old meets the new

Diana Hinds
guardian.co.uk

A larger | smaller

The three things that 15-year-old Alan Amin most disliked about his school before it was remodelled were the toilets ("not up to scratch"), the dull, dark corridors, and the fact that the football pitch was surrounded by stinging nettles ("so you couldn't get the ball out").

The Leicester school was built in 1935 as Newark girls' grammar school, with 450 pupils. After various modifications, in the late 1990s it became [redacted], an 11-16 comprehensive, with double the number of students. When Michael McPherson took over as head two years ago, the school was no longer "fit for purpose".

"It felt cramped," he says. "The corridors and stairwells were restricted, and although some of the classrooms were bigger than are required now, some were significantly smaller. Opportunities for small group work or the personalised curriculum were just not available."

Designs were already underway for an additional building, attached to the main school by a walkway, but McPherson and his staff were not satisfied. "The plans did not meet our educational vision," he says. "This is a school facing challenging circumstances: we wanted to do something quite transformational."

What they came up with, courtesy of [redacted] was a £12m partial rebuild plus a refurbishment of existing facilities which is due to be completed by October next year. The school retains its 1930s red-brick facade and clock tower, which McPherson says is "quite iconic within the local community", but this now becomes the back of the school.

At the front stands a new three-storey extension with a striking glazed facade. The original school hall, to be restored to 1930s decor, projects out of the old building and into the new, its outer walls in the new building painted lime green.

"We don't want to get rid of the old school because there are memories there," says Helen Carvell, aged 15.

The new building, which opens in January 2009, increases teaching and circulation space, with wide corridors and new stairwells, while the smaller rooms in the old building will be used for music practice, special needs teaching and offices.

"The new corridors look really magnificent," says pupil Alan Amim, who is also delighted with the new football pitch surrounded by a high fence.

Helen Carvell is looking forward to new toilets, faster computers and "brighter colours to help lift the mood of students. "I think it will be more cheerful," she says. "It'll be a nice, new atmosphere."

Weblink

[redacted]

Sustainability Matrix (Gething and Bordass, 2006, p.418)

	1. GOOD PRACTICE	2. BEST PRACTICE	3. INNOVATIVE	4. PIONEERING	NOTES
1. CO_2 Emission Target	40kgCO_2/m^2/yr	30kgCO_2/m^2/yr	15kgCO_2/m^3/yr	"Carbon neutral" 0kgCO_2/m^2	Industry standard EEO targets
2. Heating Load Target	79kWhr/m^2/yr	47kWhr/m^2/yr	30kWhr/m^2/yr	20kWhr/m^2/yr	Industry standard EEO targets
3. Electrical Load Target	54kWhr/m^2/yr	43kWhr/m^2/yr	35kWhr/m^2/yr	25kWhr/m^2/yr	Industry standard EEO targets
4. U Values: Wall Average Window Roof Ground Floor	0.35 2.2 0.2 0.25	0.25 1.8 0.18 0.22	0.2 1.4 0.15 0.2	0.1 0.9 0.1 0.1	good practice=current building regulations pioneering=Bedzed values
5. Airtightness	<10m^3/hr/m^2	<8m^3/hr/m^2	<5m^3/hr/m^2	<3m^3/hr/m^2	All measures require careful attention to details and monitoring construction.
6. Ventilation	Natural ventilation where possible. Mechanical ventilation where not.	Designed natural ventilation with automatic openers, mechanical ventilation to WCs etc.	Mechanical ventilation with heat reclaim in winter and BMS controlled natural ventilation in summer.		BMS with manual overrides preferable on all windows.
7. On Site Energy Generation		Solar domestic water heating to WCs.	Solar domestic water heating to WC cores. Cost effective PV installation using PVs to shade rooflights. Gas fired CHP installation.	Solar water heating to kitchens. Maximum PV installation using most efficient PVs. Wood/waste fired CHP.	Potential 50% grant available from DTI for solar water heating, up to 65% for PV installation.
8. Daylighting	"Reasonable" to BS8206 part 2. A 2% daylight factor.	80% office space daylit to meet criteria of BS8206: part 2.	100% of office space daylit to BS8206 part 2		Ensure prevention of solar heat gain/glare by building form/shading systems
9. Artificial Lighting Controls	PIR detectors in WCs etc. Low energy fittings throughout.	Luminance and presence detectors throughout building. No dimming.	Luminance and presence detection at all fittings with dimming to zero and BMS override.		Personalised controls strongly recommended by the client
10. Cooling Systems/Sources	Zero ozone depletion refrigerants in high efficiency comfort cooling/air conditioning systems.	Night time structural cooling with automatic window vents.	Evaporative cooling to rooms with high internal heat gains.	Borehole/ground water cooling to rooms with high internal heat gains.	Need to provide for areas where cooling is required and provide upgrade path for entire building.
11. Embodied Energy in Structural Materials	Steel and concrete frame engineered to minimise mass of materials.	Use of cement replacements e.g. GGBFS in concrete. Use recycled steel.	Timber structure in lieu of steel or concrete but retaining concrete floors. Use of recycled aggregates in structural concrete.	All timber structure with thermal mass provided using minimum amount of concrete.	NB. Client is particularly keen on use of timber for low embodied energy

Stroma Case Study

[redacted]

As regular air-tightness testing advisors to [redacted], Stroma was appointed to secure a demanding permeability target rate of less than $5m^3/(m^2.hr)$ @ 50Pa for [redacted]

[redacted] is one of four schools to be completely remodelled under Leicester City Council's £325 million *Building Schools for the Future (BSF)* programme. The BSF is a government led initiative aimed at providing UK authorities with funds to invest in the educational needs of students. [redacted] was built to provide 1,200 pupils with high-tech learning facilities in safe and sustainable surroundings.

Designed to maximise space and attain the highest energy efficient standards, [redacted] College boasts flexible classrooms with partition walls that open up, sensors to monitor and control the internal building temperature and two 250kW chip biomass boilers.

Given the college's robust and proactive response to sustainability, it was crucial that [redacted] achieved its air permeability target of below $5m^3/(m^2.hr)$ @ 50Pa. Having worked on successful projects with Stroma previously, [redacted] trusted our ability to provide a variety of consultancy services to achieve this target.

From the outset of the project, Stroma Technology conducted design workshops to establish an air barrier strategy for the building and review any potential air leakage areas. Stroma Contracting was also called upon to provide additional works on the building, to guarantee that all interfaces were air-sealed to compliance requirements. When the building was close to completion, members of Stroma Technology conducted a final detailed inspection, in order to verify that preparations were complete for our team to conduct the concluding UKAS accredited air-tightness test.

[redacted] surpassed its target of $5m^3/(m^2.hr)$ @ 50Pa, with an air permeability rate of $4.68\ m^3/(m^2.hr)$ @ 50Pa. Given the college's size and complex geometry, this was a well received result.

Stroma was employed for all the [redacted], including [redacted] (shortlisted for 'Best Use of Outside Space' and 'Innovation in PE & Sport' in the 2009 *BSF Excellence Awards*) and [redacted] (winner of 'Best BSF School' and 'Grand Prix Award for Best Overall BSF project').

Project: [redacted]

Air Tightness Tests

Client: Leicester City Council (BSF)

Contractor: Miller Construction

As regular air-tightness testing advisors to [redacted], Stroma Technology was commissioned to undertake the air-tightness testing of [redacted], Leicester.

This 'Exceptional Centre of Learning' was developed under the government's Building Schools for the Future (BSF) programme; an initiative providing UK authorities with funds to invest in the educational needs of all students. As one of four educational developments to benefit from Liecester's Â£235 million BSF grant, [redacted] was built to provide 1,275 pupils with high-tech facilities in strictly sustainable surroundings.

Designed to a BREEAM rating of 'Excellent', the college possesses extensive renewable installations, including solar thermal hot water, photovoltaic panels, a wind turbine, and large biomass boiler. With mixed-mode ventilation and a high-efficiency heat recovery system, the development achieves 20% of its energy generation on-site whilst sustaining a low-energy consumption level.

Stroma Technology was commissioned by Miller Construction to ensure that the college achieved its air-tightness target of $5m^3/hr.m^2$ @ 50 Pa. From the outset of the project, out team of expert air-tightness testers provided design consultation and advice. Following a comprehensive design review, Stroma conducted a series of detailed onsite audits, in order to identify any problems during the construction process. After paying a final visit to the school one week prior to the test, to ensure all preparations were complete, Stroma Technoology performed a UKAS accredited air-tightness test.

Project: [redacted]

Client: Leicester City Council

Air Tightness Tests

Contractors: Miller Construction

Stroma Technology was recently appointed by Miller Construction to undetake the air-tightness testing and consultancy of award-winning [redacted] Leicester.

[redacted] was the first of four schools to partake in Leicester's Â£235M Building Schools for the Future (BSF) funding framework. Designed to an 'Excellent' BREEAM standard, the new-build incorporates the use of biomass boilers, heat exchange, below ground drainage attenuation and other energy conservation technologies.

As an exemplary example of the positive impact of sustainable design within the community, it was crucial that [redacted] achieved an air-tightness result of $5m^3/hr.m^2$ @ 50 Pa.

Stroma Technology was therefore employed by Miller Construction to provide the necessary design advice and consultation for attaining this target. Stroma's initial step was to conduct a comprehensive design review of the development, leading to the establishment of an over-arching air-barrier design strategy. After this, Stroma Technology performed a detailed on-site audit inspections of the development, during key intervals of the construction plan. Our experienced air-tightness consultants spent a day at a time on site, reviewing relevant air barrier details and producing illustrated reports in order to assess the ongoing performance of the building, and feed back the observations to Miller Construction. Prior to the final test, Stroma visited the site to ensure all pre-test preperations were complete. Upon confirmation that the school was ready, Stroma performed a UKAS accredited air-tightness test.

Stroma's appointment from the early stage of construction led to the school achieving a compliance result of $4.74m^3/hr.m^2$ @ 50Pa. Being an outstanding sustainable building, the school has won 'Best BSF School' and 'Grand Prix Award for Best Overall BSF Project' in the 2009 BSF Excellence Awards.

Stroma was employed by Miller Construction for all the Leicester BSF projects, including [redacted] which was shortlisted for 'Best Use of Outside Space' and 'Innovation in PE & Sport' in the BSF Awards.

Details of ICT Infrastructure

Latest News

ICT In Leicester City BSF Schools

northgate
MANAGED SERVICES

While BSF does include new school buildings, it is intended as far more than a simple building project. Using ICT to support new approaches to teaching and learning enables students to learn outside the normal school routine and offers access to a new and exciting range of information and resources. Through extended opening hours, the new facilities are available for use by the whole community.

Northgate Managed Services was appointed ICT managed service provider as part of Leicester City's BSF programme in December 2007.

There are four schools in Phase 1 - all of which have opened in the first half of 2009:

Northgate's ICT Managed Service

Northgate Managed Services has worked closely with the schools and LMEC to tailor and personalise technology. This has ensured that the ICT needs of students are met, as well as the education vision of the schools. Keen to help students take ownership of their own learning, the common technology vision for the schools is to strongly emphasise personalisation and the provision of anytime, anywhere learning.

Also committed to supporting the schools on a day-to-day basis through its managed service, each of the school's networks and infrastructures is supported and continuously monitored by Northgate's dedicated Service Desk. The service, modelled on industry best practice, promotes high first-time fix rates and provides the schools with a proactive and continuously improving service that ensures ICT incidents and problems are managed efficiently to minimise disruption to teaching and learning. The Service Desk, together with the dedicated on-site team, provides an integrated managed service, supplemented where required with resources drawn across Northgate, ensuring maximum flexibility and secure efficient delivery.

N-able Managed Learning Environment (MLE)

Each student within the completed BSF Schools now has access to an on line Managed Learning Environment (MLE) called N-able. Designed by Northgate, N-able provides students with their own personalised learning area with the support and assistance they need to maximise independent study and to progress according to their own individual learning plan. Accessible through the internet from any location, the MLE gives each student their own on line space to work on assignments, store work and access emails, enabling them to communicate with teachers and fellow students.

Each teacher has a digital tool box to enable them to continually assess pupils' work and offer as much or as little guidance as they need. N-able also allows the school to incorporate administrative systems such as pupil access and registration, as well as pupil achievements such as exam and homework marks.

Over the course of the project, N-able will provide parents with secure access to information about their child such as their attendance, homework assignments and assessments. Leicester parents are able to keep up to date with their child's achievements online and really get involved in their child's education, improving communication between parents, school and students.

Implementation of N-able has been tailored to the requirements of the individual school, with each school integrating with different administration systems such as registration, student assessment and cashless catering.

Lighting Summary Report by Thorlux to evaluate School A

Thorlux have managed to reduce the quantity and wattage of luminaires in most areas across the school.

The Thorlux design can save around 53.4% less energy than the current operational scheme.

By using the SMART system there will be no LCM's, additional PIR's or light sensors to install therefore, reducing installation cost considerably.

The SMART system is a plug and play system enabling the connections to be quick and easy to install. This can reduce the installation cost.

Areas that we found to be under-lit were corrected to meet the specification. This meant that we had to increase the quantity of luminaires within these areas.

Entrance lobby uses pendants with separate emergency luminaires. We have proposed a similar product but with integral emergency reducing installation cost.

We have proposed replacing LED downlights for recessed fluorescent wall washers to light display boards within the library. After viewing the LED downlighters on site, we found they were not providing an even or powerful enough light for the display.

When comparing the operational scheme with the Thorlux design, you can see that you could save around 53.4% of energy.

This is done by reducing the wattage and quantity of luminaires on the project and with the use of full room dimming via our SMART system.

The quantity of luminaires has been reduced from 1,693 to 1,479 where the majority of luminaire wattages being reduced from 66 circuit watts down to 61.5 circuit watts.

This saving in energy can be translated into 44.5 tonnes of CO_2 per year off the operational scheme and a running cost saving of £8,403.04 per year.

The current system

Energy Consumption

Operational Scheme

Project Information	Electricity Tariff	£0.10	Burning Hours	2000
	Presence Detection %	70	Daylight %	70

Description	No. Luminaires	Luminaire Circuit Watts	Total Circuit Watts (including losses)	Total Power Usage (kW)	Annual Power Usage (kW) (Presence)	Annual Power Usage (kW) (Daylight+ Presence)	Annual CO^2 Production*	Trees Required per annum**
4 x 14w HF	533	66	35178	70,356.00	49,249.20		26102.08	26.10
4 x 14w HFR	201	66	13266	26,532.00		13,000.68	6890.36	6.89
2 x 24w HF	105	52	5460	10,920.00	7,644.00		4051.32	4.05
2 x 24w HFR	41	53	2173	4,346.00		2,129.54	1128.66	1.13
2 x 55w HFR	40	113	4520	9,040.00		4,429.60	2347.69	2.35
4 x 55w HF	40	226	9040	18,080.00	12,656.00		6707.68	6.71
4 x 42w HF	11	188	2068	4,136.00	2,895.20		1534.46	1.53
2 x 26w HF	285	56	15960	31,920.00	22,344.00		11842.32	11.84
26w HF	4	28	112	224.00	156.80		83.10	0.08
3 x 1.2w HF	5	3.6	18	36.00	25.20		13.36	0.01
2 x 54w HF	46	117	5382	10,764.00	7,534.80		3993.44	3.99
54w HF	24	60	1440	2,880.00	2,016.00		1068.48	1.07
35w HF	10	39	390	780.00	546.00		289.38	0.29
2 x 35w HF	31	76	2356	4,712.00	3,298.40		1748.15	1.75
55w 2D, HF	93	60	5580	11,160.00	7,812.00		4140.36	4.14
28w 2D, HF	38	31	1178	2,356.00	1,649.20		874.08	0.87
3 x 24w HF	165	80	13200	26,400.00	18,480.00		9794.40	9.79
3 x 24w HFR	13	81	1053	2,106.00		1,031.94	546.93	0.55
50w MR16 Low voltage	5	50	250	500.00	350.00		185.50	0.19
Unknown	3		0	0.00	0.00		0.00	0.00
Total	**1693**		**118,624.00**	**237,248.00**	**136,656.80**	**20,591.76**	**83,342**	**83.3**

Total Annual Power Usage (kW)	**157,248.56**
Total Annual CO^2 Production*	**83,341.74**
Total Running Cost (per annum)	**£15,724.86**

The proposed system

Energy Consumption

Thorlux

Project Information	Electricity Tariff	£0.10	Burning Hours	2000
	Presence Detection %	70	Daylight %	40

Description	No. Luminaires	Luminaire Circuit Watts	Total Circuit Watts (including losses)	Total Power Usage (kW)	Annual Power Usage (kW) (Presence)	Annual Power Usage (kW) (Daylight+ Presence)	Annual CO^2 Production*	Trees Required per annum**
4 x 14w SMART	348	66.5	23142	46,284.00		12,959.52	6868.55	6.87
2 x 55w SMART	10	117.3	1173	2,346.00		656.88	348.15	0.35
38w HF	98	41	4018	8,036.00	5,625.20		2981.36	2.98
28w HF	44	31	1364	2,728.00	1,909.60		1012.09	1.01
2 x 35w, HF	79	76	6004	12,008.00	8,405.60		4454.97	4.45
1 x 35w, HF	28	39	1092	2,184.00	1,528.80		810.26	0.81
4 x 80w HF	25	342	8550	17,100.00	11,970.00		6344.10	6.34
4 x 42w, HF	11	188	2068	4,136.00	2,895.20		1534.46	1.53
1 x 55w SMART	459	61.5	28228.5	56,457.00		15,807.96	8378.22	8.38
1 x 40w SMART	285	43	12255	24,510.00		6,862.80	3637.28	3.64
2 x 40w SMART	83	87.9	7295.7	14,591.40		4,085.59	2165.36	2.17
1 x 40w HF	5	45	225	450.00	315.00		166.95	0.17
32w HF	4	35	140	280.00	196.00		103.88	0.10
Total	**1479**		**95,555.20**	**191,110.40**	**32,845.40**	**40,372.75**	**38,806**	**38.8**

Total Annual Power Usage (kW)	**73,218.15**
Total Annual CO^2 Production*	**38,805.62**
Total Running Cost (per annum)	**£7,321.82**
Annual Power Usage Saving	84,030.41
Total Annual CO^2 Production* Saving	44,536.12
Total Running Cost (per annum) Saving	£8,403.04
Percentage Saving (%)	53.4%

FM staff were reluctant to have their comments recorded using a dictaphone.

As a result, the research made ad-hoc notes of meetings as shown below.

Meeting with FM Staff member : May 28th Friday 2010

Judge Meadows issues:
- Paul Fleming's position as governor prevents him from divulging particular information.
- They have a 2 year Contract.
- The buildings will be re-assessed to measure performance after 2/3 years.
- Lighting represents 70% of Electricity.
- Bidding for the lighting is based on cost of Installation and preferred Supplier is favoured.
- Energy Efficiency is <u>NOT</u> built in to the bidding application for Lighting.
- Patrick has initiated a survey by another Electrical Lighting specialists. Their brochure claims to save 50%.
- BEMS Comissioning needs careful tweaking and should be done straight away.
- Underfloor heating response time too slow
- Premium / Priority is Size, radiators reduce floor Space. Air tightness improvements indicate in our temperate and variable climate under floor heating is NOT Suitable or affordable....

Solutions to the Solar Gain Problems cited at School C

Sipoo High School,
Sipoo Nikkilä, Finland –
Pilkington **Suncool**™ 66/33

Energy efficiency in buildings

Today's increased use of glass in architecture and the ever-growing focus on energy efficiency are driving building developers, owners and occupants to demand higher-performing products than ever before.

Buildings are increasingly becoming the focus of energy-saving initiatives not only because they are a significant energy-consuming sector, but the technologies and products to make buildings substantially more energy-efficient have already been developed. Continuing developments in glass technology, such as low-emissivity and solar control, have revolutionised the potential of glazing applications. Improving the energy-efficiency of buildings also means that they are more comfortable and cheaper to run for the owner and occupier.

Pilkington United Kingdom Ltd as part of the NSG Group is continually developing products to help specifiers achieve reduced carbon emissions. In buildings that would traditionally be air-conditioned or use high levels of artificial lighting our solar control glass rejects unwanted solar radiation but transmits valuable daylight. Conversely, our energy saving low-emissivity glass reduces heat loss from buildings and, in some cases, our products combine both low-emissivity and solar control performance.

Advanced products from the Pilkington range enable buildings to be both energy-efficient and attractive. Glass can be used as a positive contributor to low-energy performance, whilst creating interiors that are comfortable and façades which connect the occupant with the outside world. A good choice of glass manages internal comfort by controlling direct radiation, glare, internal temperature and light levels as well as saving capital and running costs.

The Light Building, Leeds – Pilkington **Suncool**™ 66/33

Pilkington **Suncool**™

Pilkington **Suncool**™ is a range of superior solar control products with a wide range of visible light transmittance, reduced solar transmittance and excellent low-emissivity all in one superb product. The excellent solar control properties of Pilkington **Suncool**™ can greatly reduce the need for air conditioning within a building, whilst its insulation properties can reduce heat loss to 1.0 W/m²K in a standard Insulating Glass Unit (6-16-6). With its extensive range, Pilkington **Suncool**™ offers the ideal choice for providing maximum light transmission and thermal comfort for occupants all year round.

Pilkington **Suncool**™ glass incorporates a thin, sputtered, metal oxide coating applied off-line. This method is used to obtain different types of coatings to offer a range of properties, increasing freedom of design and aesthetic options and ensuring efficient use of light and heat. Depending on the individual application a wide range of appearance and performance options are available.

Pilkington **Suncool**™ products are suitable for commercial and residential applications that demand high light transmission properties. They are designed to achieve optimum performance in large glazed areas and are available in a wide range of performances.

Pilkington **Suncool**™ must be incorporated in an Insulating Glass Unit with the coating on the inside surface of the outer pane. The Pilkington **Suncool**™ range of products can be used with many other Pilkington solutions, to achieve countless benefits in terms of functionality and cost-efficiency.
Pilkington **Suncool**™ products are available in annealed, toughened, laminated and sound insulation form and on Pilkington **Optiwhite**™.*
In addition, Pilkington has developed a range of spandrel products for the Pilkington **Suncool**™ range to allow continuity of appearance from spandrel to vision areas of glazing.

*Pilkington **Optiwhite**™ is a low iron glass with improved light and solar transmittance properties. It can be used as the substrate for most Pilkington **Suncool**™ products or on its own to take advantage of desirable solar heat and light transmittance.

Trend Re-commissioning Reports

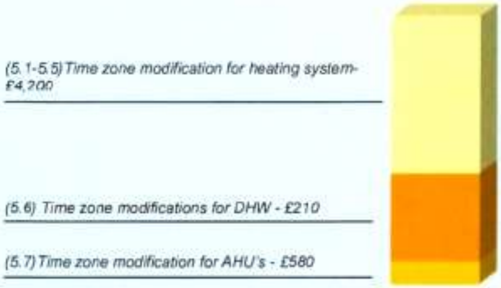
Actions and Recommendations

Controls Energy Audit

This report is a summary of the activity and findings from a site visit to Leicester. The purpose of this visit was to review the energy consumption and utilisation at the site and to investigate, and where possible implement, energy efficiencies within the Trend Building Energy Management System.

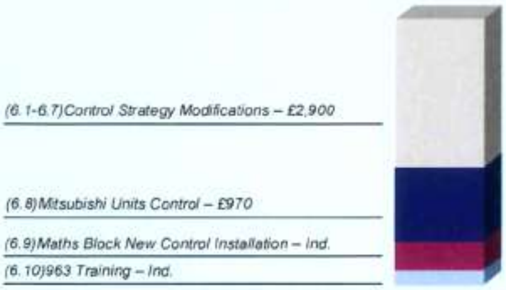
EXECUTIVE SUMMARY

Energy optimisation activities and savings
Implemented changes – The savings detailed are based on changes made during the Controls Energy Audit and will therefore require no additional investment.



TOTAL SAVINGS: £4,990

Pending changes — Additional potential that can be achieved subject to additional investment.



TOTAL Potential SAVINGS: £3,870

System operational risk review

Recommended	Control Strategy Modifications
	Mitsubishi Units Control
	Boiler Control
	963 Training for Site Personnel

Report Ref BN/SVC/0910

Site name:

Address:

Contact:

Site visit:

Trend Engineer:

Report Contents

Energy Savings	£
Savings Already Made	4,990
Total Potential Savings	3,870
Energy Usage	**kWh**
Savings Made	173,885
Potential Savings	64,220
Tonnes of CO_2	**CO_2**
Savings Made	39
Potential Savings	24
Operational Risks	
Essential Issues	0

TREND

Actions and Recommendations

Controls Energy Audit

This report is a summary of the activity and findings from a site visit to [redacted] Leicester. The purpose of this visit was to review the energy consumption and utilisation at the site and to investigate, and where possible implement, energy efficiencies within the Trend Building Energy Management System.

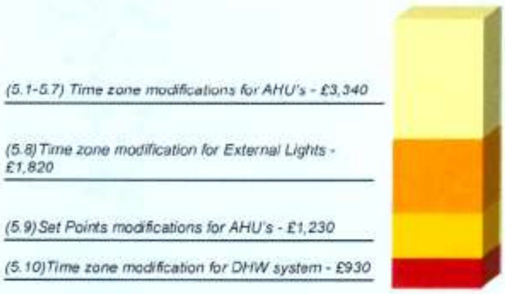
Report Ref BN/SVC/0910

Site name:	[redacted]
Address:	
Contact:	
Site visit:	
Trend Engineer:	

EXECUTIVE SUMMARY

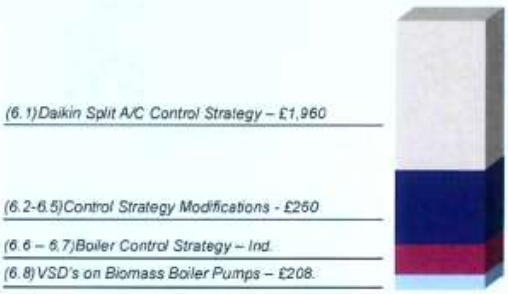
Energy optimisation activities and savings

Implemented changes – The savings detailed are based on changes made during the Controls Energy Audit and will therefore require no additional investment.



TOTAL SAVINGS: £7,320

Pending changes — Additional potential that can be achieved subject to additional investment.



TOTAL Potential SAVINGS: £2,420

System operational risk review

Recommended	Daikin Split A/C Units Control
	Control Strategy Modifications
	Boiler Control
	963 Training for Site Personnel

Report Contents

Energy Savings	£
Savings Already Made	7,320
Total Potential Savings	2,420
Energy Usage	**kWh**
Savings Made	179,350
Potential Savings	24,330
Tonnes of CO_2	**CO_2**
Savings Made	48
Potential Savings	13
Operational Risks	
Essential Issues	0

TREND

Actions and Recommendations

Controls Energy Audit

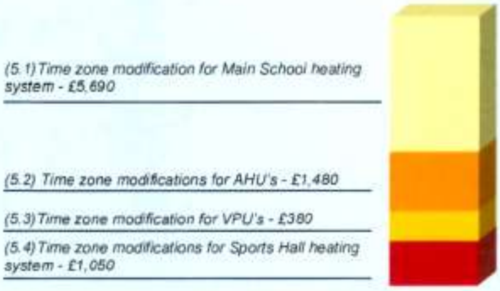
This report is a summary of the activity and findings from a site visit to [redacted] Leicester. The purpose of this visit was to review the energy consumption and utilisation at the site and to investigate, and where possible implement, energy efficiencies within the Trend Building Energy Management System.

Report Ref BN/BLS/1010

Site name:
Address:
Contact:
Site visit:
Trend Engineer:
[redacted]

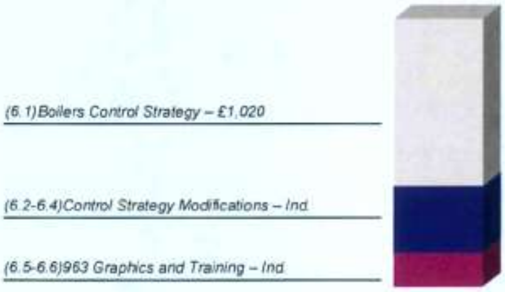
EXECUTIVE SUMMARY

Energy optimisation activities and savings
Implemented changes – The savings detailed are based on changes made during the Controls Energy Audit and will therefore require no additional investment.



TOTAL SAVINGS: £8,580

Pending changes — Additional potential that can be achieved subject to additional investment.



TOTAL Potential SAVINGS: £1,020

System operational risk review

Recommended	Boiler Control Strategy
	Control Strategy Modifications
	963 Graphics and Training for Site Personnel

Report Contents

Energy Savings	£
Savings Already Made	8,580
Total Potential Savings	1,020
Energy Usage	**kWh**
Savings Made	184,800
Potential Savings	25,248
Tonnes of CO_2	**CO_2**
Savings Made	41
Potential Savings	5
Operational Risks	
Essential Issues	0

TREND

Actions and Recommendations

Controls Energy Audit

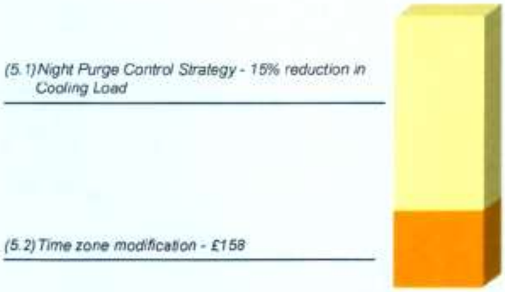
This report is a summary of the activity and findings from a site visit to [redacted] Leicester. The purpose of this visit was to review the energy consumption and utilisation at the site and to investigate, and where possible implement, energy efficiencies within the Trend Building Energy Management System.

Report Ref GH/FCC/0910

Site name:	[redacted]
Address:	
Contact:	
Site visits:	
Trend Engineer:	

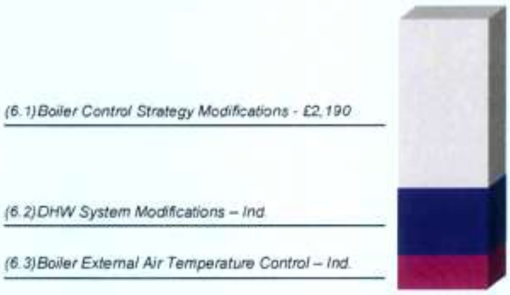
EXECUTIVE SUMMARY

Energy optimisation activities and savings
Implemented changes – The savings detailed are based on changes made during the Controls Energy Audit and will therefore require no additional investment.



TOTAL SAVINGS: £158

Pending changes — Additional potential that can be achieved subject to additional investment.



TOTAL Potential SAVINGS: £2,190

System operational risk review

Recommended	Optimum Stop Control Strategy
	Boiler Control Strategies
	Mechanical Cooling Provision

Report Contents

Energy Savings	£
Savings Already Made	158
Total Potential Savings	2,190
Energy Usage	**kWh**
Savings Made	1,580
Potential Savings	54,028
Tonnes of CO_2	**CO_2**
Savings Made	1
Potential Savings	10
Operational Risks	
Essential Issues	0

TREND

School B 2010 DEC Advisory Report (Gas, Electric & Biomass Data)

1. Background

Statutory Instrument 2007 No. 991, *The Energy Performance of Buildings (Certificates and Inspections) (England and Wales) Regulations 2007* , as amended, transposes the requirements of Articles 7.2 and 7.3 of the Energy Performance of Buildings Directive 2002/91/EC.

This report is an Advisory Report as required under regulations 16(2)(a) and 19 of the Statutory Instrument SI 2007/991.

This section provides general information regarding the building:

Total Useful Floor Area (m²):	13300
Building Description:	Secondary school with community use
Building Environment:	Heating and Mechanical Ventilation
On-site renewable energy sources:	Biomass Boiler and Solar pV
Separable energy uses discounted:	None

Fuel Types:	**Quantity used (kWh)**
Natural Gas	1462897
Electricity	576393
Biomass	205308

2. Introduction

This Advisory Report was produced in line with the Government's approved methodology and is based on assessment software CLG, ORCalc, v3.0.1. This advisory report was developed based on a physical visit of the building.

In accordance with Government's current guidance, the Energy Assessor did undertake a walk around survey of the building on 24/06/2010 prior to producing this Advisory Report.

School C 2010 DEC Advisory Report (Gas, Electric & Biomass Data)

1. Background

Statutory Instrument 2007 No. 991, *The Energy Performance of Buildings (Certificates and Inspections) (England and Wales) Regulations 2007* , as amended, transposes the requirements of Articles 7.2 and 7.3 of the Energy Performance of Buildings Directive 2002/91/EC.

This report is an Advisory Report as required under regulations 16(2)(a) and 19 of the Statutory Instrument SI 2007/991.

This section provides general information regarding the building:

Total Useful Floor Area (m^2):	12000
Building Description:	Secondary school with community use
Building Environment:	Heating and Mechanical Ventilation
On-site renewable energy sources:	Biomass Boiler
Separable energy uses discounted:	None

Fuel Types:	**Quantity used (kWh)**
Natural Gas	1010750
Electricity	786087
Biomass	610223

2. Introduction

This Advisory Report was produced in line with the Government's approved methodology and is based on assessment software CLG, ORCalc, v3.0.1. This advisory report was developed based on a physical visit of the building.

In accordance with Government's current guidance, the Energy Assessor did undertake a walk around survey of the building on 24/06/2010 prior to producing this Advisory Report.

Display Energy Certificate

How efficiently is this building being used?

HM Government

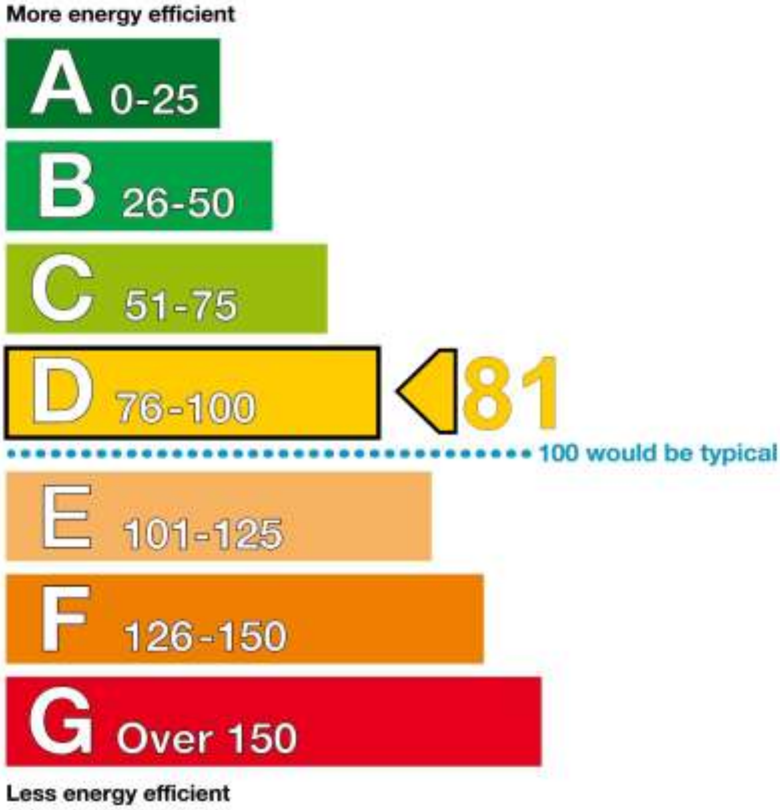
School C

Certificate Reference Number:
0420-0612-4409-2923-7006

This certificate indicates how much energy is being used to operate this building. The operational rating is based on meter readings of all the energy actually used in the building. It is compared to a benchmark that represents performance indicative of all buildings of this type. There is more advice on how to interpret this information on the Government's website www.communities.gov.uk/epbd.

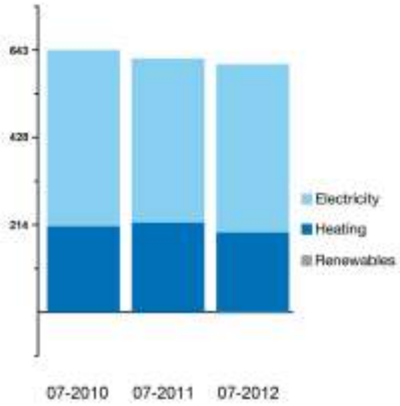
Energy Performance Operational Rating

This tells you how efficiently energy has been used in the building. The numbers do not represent actual units of energy consumed; they represent comparative energy efficiency. 100 would be typical for this kind of building.



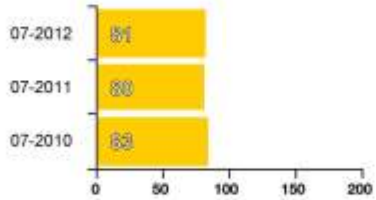
Total CO_2 Emissions

This tells you how much carbon dioxide the building emits. It shows tonnes per year of CO_2.



Previous Operational Ratings

This tells you how efficiently energy has been used in this building over the last three accounting periods



Technical information

This tells you technical information about how energy is used in this building. Consumption data based on actual meter readings.

Main heating fuel: Natural Gas
Building Environment: Heating and Natural Ventilation
Total useful floor area (m^2): 12000
Asset Rating: Not available.

	Heating	Electricity
Annual Energy Use (kWh/m²/year)	90	62
Typical Energy Use (kWh/m²/year)	175	52
Energy from renewables	1.2%	0.0%

Administrative information

This is a Display Energy Certificate as defined in SI 2007/991 as amended.

Assessment Software: SystemsLink, ORToolkit, v3.6
Property Reference: 220476940000
Assessor Name: Stephanie Temme
Assessor Number: STRO005420
Accreditation Scheme: Stroma Certification Ltd
Employer/Trading Name: G4S Integrated Services (UK) Ltd
Employer/Trading Address: Farncombe House, Broadway, WR12 7LJ
Issue Date: 31-07-2012
Nominated Date: 13-07-2012
Valid Until: 12-07-2013
Related Party Disclosure: Contractor to the occupier for EPB services only

Recommendations for improving the energy efficiency of the building are contained in the accompanying Advisory Report.

Display Energy Certificate
How efficiently is this building being used?

HM Government

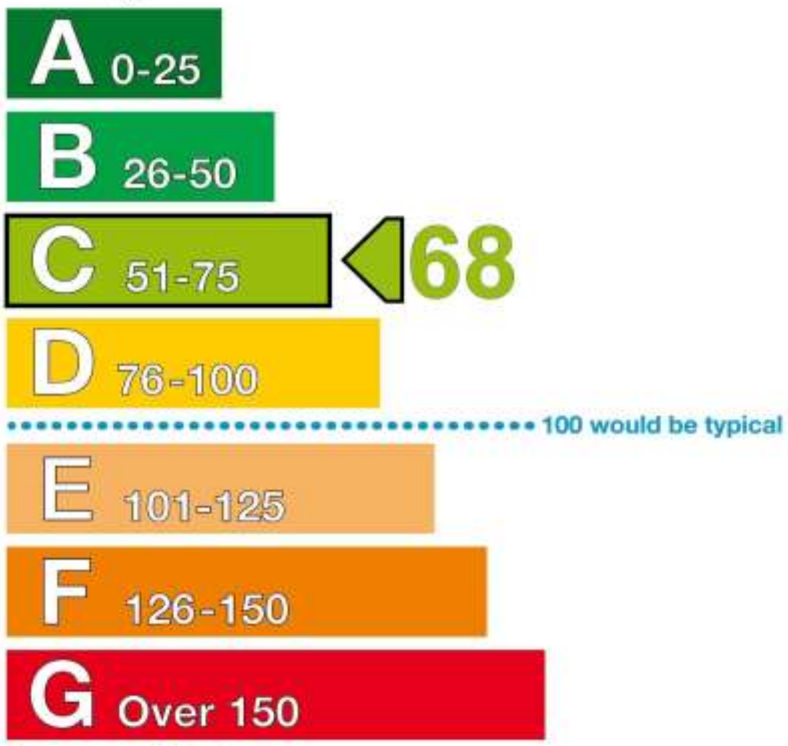
School B

Certificate Reference Number:
0410-0112-7799-8923-9002

This certificate indicates how much energy is being used to operate this building. The operational rating is based on meter readings of all the energy actually used in the building. It is compared to a benchmark that represents performance indicative of all buildings of this type. There is more advice on how to interpret this information on the Government's website www.communities.gov.uk/epbd.

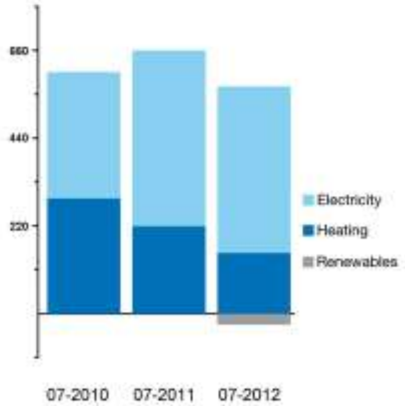
Energy Performance Operational Rating

This tells you how efficiently energy has been used in the building. The numbers do not represent actual units of energy consumed; they represent comparative energy efficiency. 100 would be typical for this kind of building.



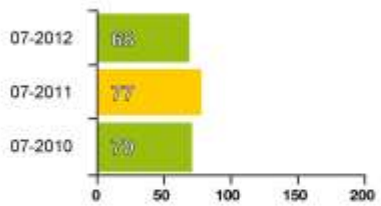
Total CO_2 Emissions

This tells you how much carbon dioxide the building emits. It shows tonnes per year of CO_2.



Previous Operational Ratings

This tells you how efficiently energy has been used in this building over the last three accounting periods



Technical information

This tells you technical information about how energy is used in this building. Consumption data based on estimates.

Main heating fuel: Natural Gas
Building Environment: Heating and Natural Ventilation
Total useful floor area (m²): 13300
Asset Rating: Not available.

	Heating	Electricity
Annual Energy Use (kWh/m²/year)	65	57
Typical Energy Use (kWh/m²/year)	174	52
Energy from renewables	11.4%	0.0%

Administrative information

This is a Display Energy Certificate as defined in SI 2007/991 as amended.

Assessment Software: SystemsLink, ORToolkit, v3.6
Property Reference: 189791970000
Assessor Name: Stephanie Temme
Assessor Number: STRO005420
Accreditation Scheme: Stroma Certification Ltd
Employer/Trading Name: G4S Integrated Services (UK) Ltd
Employer/Trading Address: Farncombe House, Broadway, WR12 7LJ
Issue Date: 31-07-2012
Nominated Date: 13-07-2012
Valid Until: 12-07-2013
Related Party Disclosure: Contractor to the occupier for EPB services only

Recommendations for improving the energy efficiency of the building are contained in the accompanying Advisory Report.

Display Energy Certificate
How efficiently is this building being used?

HM Government

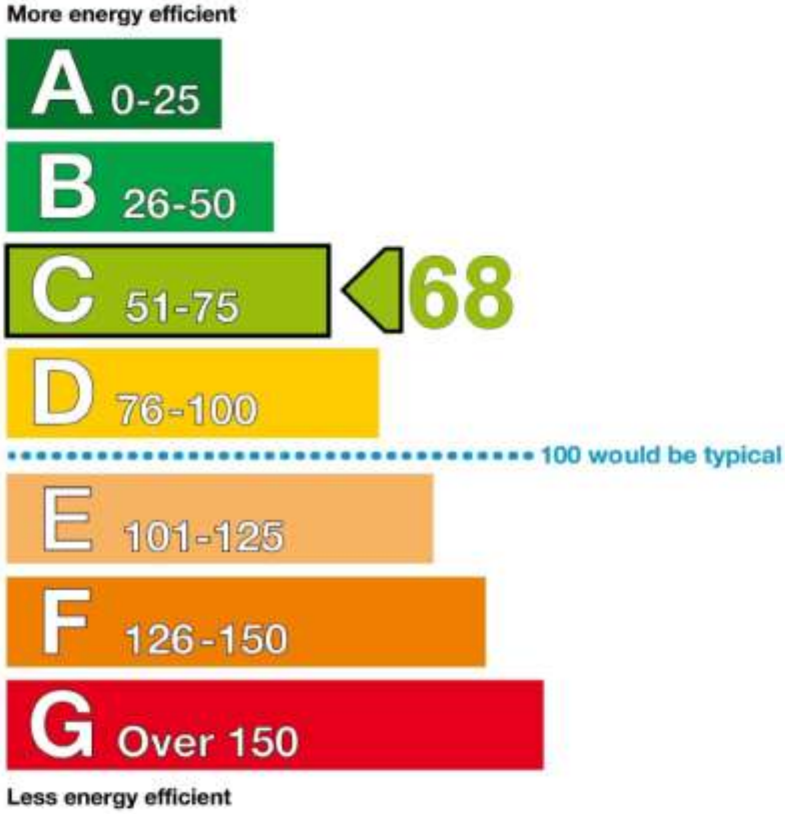
School D

Certificate Reference Number:
0482-0412-1119-1923-3002

This certificate indicates how much energy is being used to operate this building. The operational rating is based on meter readings of all the energy actually used in the building. It is compared to a benchmark that represents performance indicative of all buildings of this type. There is more advice on how to interpret this information on the Government's website www.communities.gov.uk/epbd.

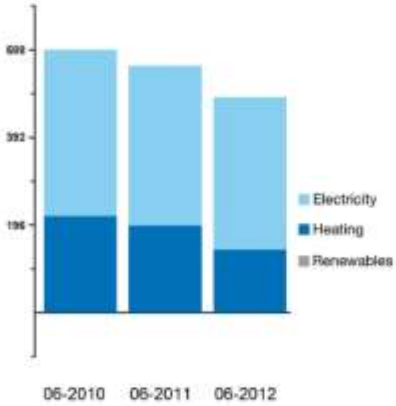
Energy Performance Operational Rating

This tells you how efficiently energy has been used in the building. The numbers do not represent actual units of energy consumed; they represent comparative energy efficiency. 100 would be typical for this kind of building.



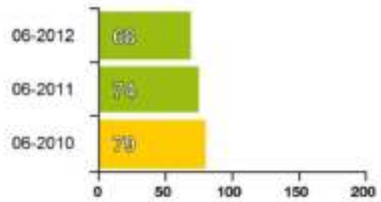
Total CO_2 Emissions

This tells you how much carbon dioxide the building emits. It shows tonnes per year of CO_2.



Previous Operational Ratings

This tells you how efficiently energy has been used in this building over the last three accounting periods



Technical information

This tells you technical information about how energy is used in this building. Consumption data based on actual meter readings.

Main heating fuel: Natural Gas
Building Environment: Heating and Natural Ventilation
Total useful floor area (m^2): 10500
Asset Rating: Not available.

	Heating	Electricity
Annual Energy Use (kWh/m²/year)	70	59
Typical Energy Use (kWh/m²/year)	183	59
Energy from renewables	0.0%	0.0%

Administrative information

This is a Display Energy Certificate as defined in SI 2007/991 as amended.

Assessment Software: SystemsLink, ORToolkit, v3.6
Property Reference: 811134910002
Assessor Name: Stephanie Temme
Assessor Number: STRO005420
Accreditation Scheme: Stroma Certification Ltd
Employer/Trading Name: G4S Integrated Services (UK) Ltd
Employer/Trading Address: Farncombe House, Broadway, WR12 7LJ
Issue Date: 31-07-2012
Nominated Date: 24-06-2012
Valid Until: 23-06-2013
Related Party Disclosure: Contractor to the occupier for EPB services only

Recommendations for improving the energy efficiency of the building are contained in the accompanying Advisory Report.

Display Energy Certificate

How efficiently is this building being used?

HM Government

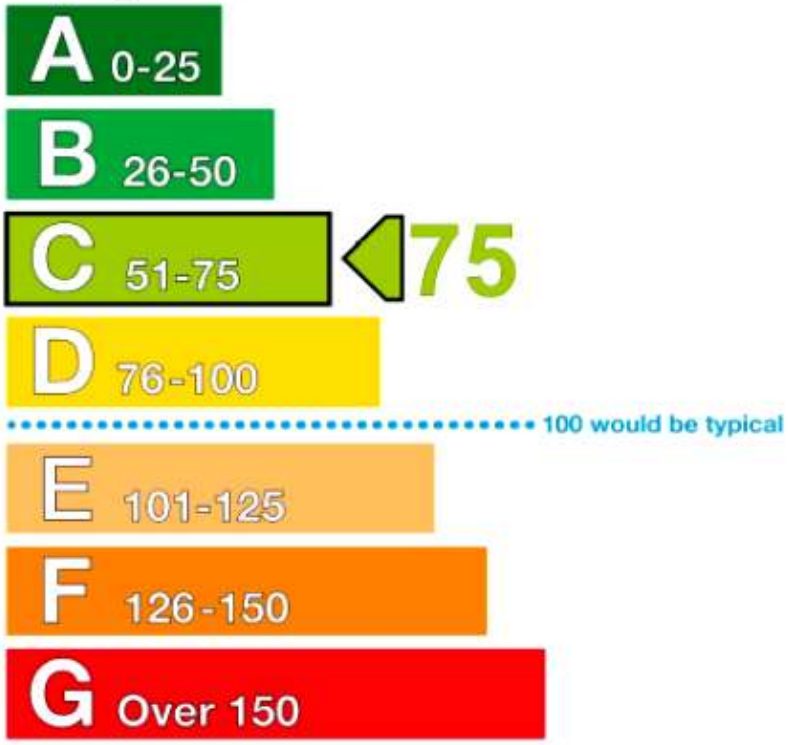
School A

Certificate Reference Number:
0692-2433-5510-4400-9203

This certificate indicates how much energy is being used to operate this building. The operational rating is based on meter readings of all the energy actually used in the building. It is compared to a benchmark that represents performance indicative of all buildings of this type. There is more advice on how to interpret this information on the Government's website www.communities.gov.uk/epbd.

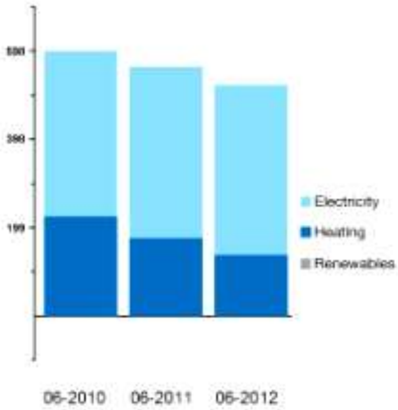
Energy Performance Operational Rating

This tells you how efficiently energy has been used in the building. The numbers do not represent actual units of energy consumed; they represent comparative energy efficiency. 100 would be typical for this kind of building.



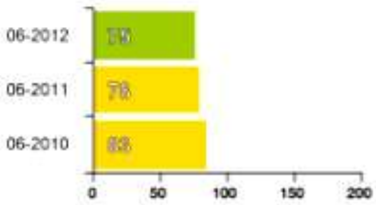
Total CO_2 Emissions

This tells you how much carbon dioxide the building emits. It shows tonnes per year of CO_2.



Previous Operational Ratings

This tells you how efficiently energy has been used in this building over the last three accounting periods



Technical information

This tells you technical information about how energy is used in this building. Consumption data based on actual meter readings.

Main heating fuel: Natural Gas
Building Environment: Heating and Natural Ventilation
Total useful floor area (m^2): 10700
Asset Rating: Not available

	Heating	Electricity
Annual Energy Use (kWh/m²/year)	67	65
Typical Energy Use (kWh/m²/year)	179	55
Energy from renewables	0.0%	0.0%

Administrative information

This is a Display Energy Certificate as defined in SI 2007/991 as amended.

Assessment Software:	SystemsLink, ORToolkit, v3.6
Property Reference:	925464530000
Assessor Name:	Stephanie Temme
Assessor Number:	STRO005420
Accreditation Scheme:	Stroma Certification Ltd
Employer/Trading Name:	G4S Integrated Services (UK) Ltd
Employer/Trading Address:	Farncombe House, Broadway, WR12 7LJ
Issue Date:	31-07-2012
Nominated Date:	24-06-2012
Valid Until:	23-06-2013
Related Party Disclosure:	Contractor to the occupier for EPB services only

Recommendations for improving the energy efficiency of the building are contained in the accompanying Advisory Report.

Display Energy Certificate

How efficiently is this building being used?

HM Government

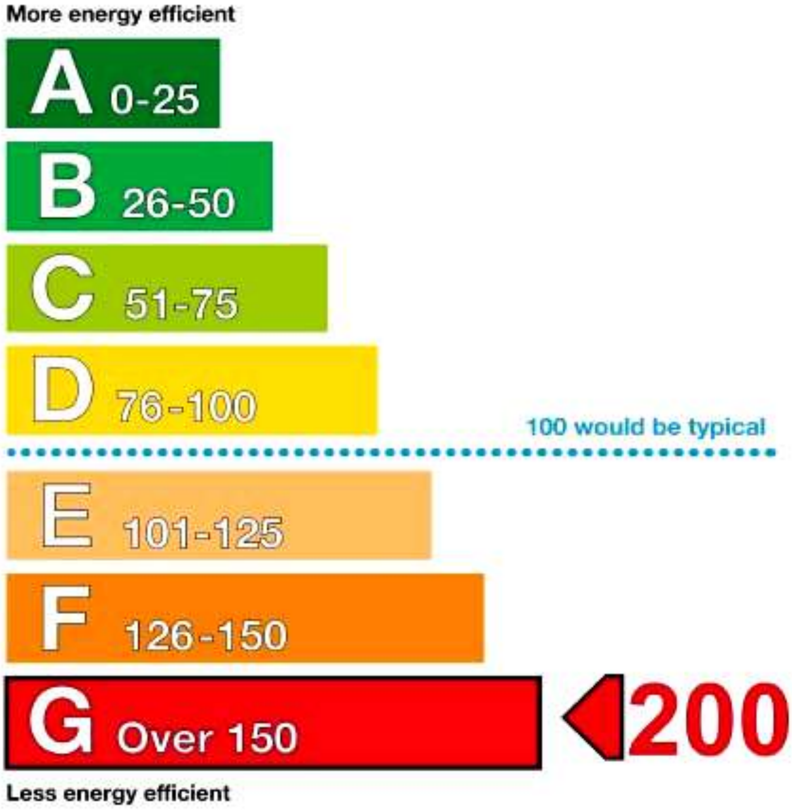
School D Gymnasium

Certificate Reference Number:
0811-1094-0111-0401-3395

This certificate indicates how much energy is being used to operate this building. The operational rating is based on meter readings of all the energy actually used in the building. It is compared to a benchmark that represents performance indicative of all buildings of this type. There is more advice on how to interpret this information on the Government's website www.communities.gov.uk/epbd.

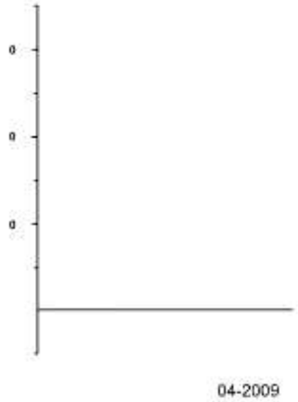
Energy Performance Operational Rating

This tells you how efficiently energy has been used in the building. The numbers do not represent actual units of energy consumed; they represent comparative energy efficiency. 100 would be typical for this kind of building.



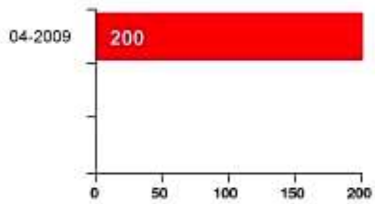
Total CO_2 Emissions

This tells you how much carbon dioxide the building emits. It shows tonnes per year of CO_2.



Previous Operational Ratings

This tells you how efficiently energy has been used in this building over the last three accounting periods



Technical information

This tells you technical information about how energy is used in this building. Consumption data based on estimates.

Main heating fuel: Natural Gas
Building Environment: Air Conditioning
Total useful floor area (m^2): 1205
Asset Rating: Not available

	Heating	Electrical
Annual Energy Use (kWh/m^2/year)	755	215
Typical Energy Use (kWh/m^2/year)	377	108
Energy from renewables	0%	0%

Administrative information

This is a Display Energy Certificate as defined in SI 2007/991 as amended.

Assessment Software:	Lifespan DEC v1.05.02
Property Reference:	811134910001
Assessor Name:	Dan Haynes
Assessor Number:	RICS300029
Accreditation Scheme:	Royal Institution of Chartered Surveyors
Employer/Trading Name:	Faithful+Gould
Employer/Trading Address:	1st Floor, The Fountain Precinct, Balm Green, Sheffield, S1 2JA
Issue Date:	17-04-2009
Nominated Date:	17-04-2009
Valid Until:	30-05-2010
Related Party Disclosure:	N/A

Recommendations for improving the energy efficiency of the building are contained in the accompanying Advisory Report.

Extract From the Loughborough University Study at School D

Case Study 1 - [redacted]

Introduction

This report is based on an initial and one subsequent visit to the project.

[redacted]s based at the school of the same name which resides within a multi-cultural, multi-deprived inner-city area in the city of Leicester. The project consists of a new 4 court sports hall, changing facilities and classroom located on the school site but detached from the main school building. The Fund have granted the project a total of £968,276 from a total cost of £1,328,276. The remainder of the money for the project came from school funds. The project was completed in May 2003 with the official opening ceremony on 10 July 2003.

It was anticipated that the new purpose built facility would allow both school and community groups to participate in a far greater range of activities at the site. This development would allow [redacted]to offer all pupils 2 hours of PE within curriculum time. A new Community Sport Co-ordinator employed by the school has been employed with the aim of developing community usage and building links with relevant groups and organisations.

A preliminary visit to the site by the whole evaluation team was undertaken on 14 May 2003 but did not form part of the evaluation. The first visit, for purposes of evaluation, was made on 5 June 2003.

Return visits were made to [redacted] December 2003 and January 2004, six months after the official opening of the facility.

Evaluation Findings

a) Partnership effectiveness

The Community Sport Co-ordinator is responsible for the day-to-day management of the facility. Her immediate line manager is the Fullhurst Business Manager and she is ultimately responsible to the school governors.

A management committee has now been set up by the Community Sport Co-ordinator. The first meeting of this committee was held in October 2003 and it was anticipated that the committee would meet quarterly. The committee consists of representatives from:

- The PE department
- Braunstone Sports Action Zone
- Positive Futures
- Braunstone Community Association
- Senior members of the school management team

This committee is chaired by the Community Sport Co-ordinator. The committee's main purpose will be to serve as a focus for development of sport for the local community with the breadth of membership hopefully bringing a range of resources and skills to the partnership. Young people were not represented directly on the committee although the school is considering developing a youth council which may provide an avenue through which young people could be represented.

The Community Sport Co-ordinator delivered an extensive 'Sports Hall Plan' at the first meeting of the management committee. The plan outlined the following objectives for [redacted]

1. Provide a sports programme aimed at encouraging all students, staff and local community members to participate in regular exercise and competition regardless of ability, which are diverse in nature and reflect the needs of the local community
2. Maximise the potential of the facility and the income without discouraging 'minority groups' e.g. low income, ethnic minority, disabled, female and girls
3. Place Fullhurst on the map as a key provider for various sports activities
4. Improve the provision of P.E. and sport across a family of schools both within and beyond the normal curriculum in order to raise standards
5. Provide a comprehensive range of vacation based courses for children between the ages 5-14 from foundation to excellence
6. Structure community sports clubs to a high standard allowing all participants to maximise their potential
7. Provide opportunities for sports centre users and local residents to qualify as coaches in a chosen sport in conjunction with NGB s
8. Promote sporting excellence through the provision of extra curricular opportunities and specialist coaching, currently unavailable for identified gifted and talented pupils

(These aims are quoted directly from the [redacted] Sports Hall Plan)

It is apparent from the 'Sports Hall Plan' that the Community Sport Co-ordinator has been responsible for all aspects of the operation of the new facility including:

- Recruiting and inducting staff
- Developing cleaning plans, staff rotas, equipment inventories,
- Developing a lettings policy
- Acquiring additional sponsorship
- Marketing the facility
- Developing monitoring and evaluation systems
- Developing and implementing the facility timetable
- Writing an action plan complete with costings

LA's POE DATA: School C

Admin staff

Prior to occupancy - March 2009

The Environment	5 Excellent		4 Good		3 Satisfactory		2 Poor		1 Unacceptable		Mar-09	Respondents
Natural Light	2	10	1	4	4	12		0		0	3.71	7
Artificial Light		0	1	4	5	15	1	2		0	3.00	7
Ventilation		0		0	4	12	3	6		0	2.57	7
Temperature (Winter)		0	1	4	4	12		0	2	2	2.57	7
Temperature (Summer)		0	1	4	3	9	3	6		0	2.71	7
Noise		0		0	5	15	2	4		0	2.71	7
Circulation spaces		0		0	4	12	2	4		0	2.67	6
Decoration		0		0	3	9	4	8		0	2.43	7
Display Spaces		0	2	8	3	9	2	4		0	3.00	7
Parking		0		0	2	6	5	10	1	1	2.13	8
Classroom space		0	1	4	3	9		0		0	3.25	4
Storage		0		0	3	9	2	4	1	1	2.33	6
Security		0		0	2	6	5	10		0	2.29	7
Dining Space		0	1	4	3	9	3	6		0	2.71	7
Staff Toilets		0		0	1	3	3	6	1	1	2.00	5
Student Toilets		0		0	1	3	4	8	1	1	2.00	6
Office space		0		0	4	12	2	4		0	2.67	6
Student recreational spaces		0	1	4	3	9		0		0	3.25	4
Spaces exclusively for staff		0		0	3	9	3	6		0	2.50	6
Spaces for parental interviews		0		0	2	6	3	6	1	1	2.17	6
Library / Resource centre		0		0	5	15	1	2		0	2.83	6
Classroom furniture		0	2	8	3	9	1	2		0	3.17	6
Acoustics		0		0	5	15		0		0	3.00	5
Building Satisfaction Index											2.68	

Post Occupancy - July 2009

The Environment	5 Excellent		4 Good		3 Satisfactory		2 Poor		1 Unacceptable		Jul-09	Respondents
Natural Light	2	10	3	12	4	12	4	8	1	1	3.0714	14
Artificial Light	1	5	5	20	5	15	1	2	0	0	3.5	12
Ventilation	0	0	3	12	3	9	4	8	3	3	2.4615	13
Temperature (Winter)	0	0	0	0	0	0	1	2	0	0	2	1
Temperature (Summer)	0	0	1	4	3	9	5	10	4	4	2.0769	13
Noise	1	5	2	8	4	12	3	6	3	3	2.6154	13
Circulation spaces	1	5	7	28	4	12	1	2	0	0	3.6154	13
Decoration	1	5	5	20	7	21	0	0	1	1	3.3571	14
Display Spaces	0	0	5	20	6	18	2	4	0	0	3.2308	13
Parking	0	0	1	4	1	3	5	10	6	6	1.7692	13
Classroom space	0	0	5	20	3	9	2	4	0	0	3.3	10
Storage	1	5	1	4	1	3	5	10	2	2	2.4	10
Security	0	0	5	20	1	3	3	6	3	3	2.6667	12
Dining Space	2	10	7	28	4	12	1	2	1	1	3.5333	15
Staff Toilets	0	0	3	12	3	9	6	12	2	2	2.5	14
Student Toilets	1	5	7	28	1	3	0	0	3	3	3.25	12
Office space	0	0	6	24	2	6	4	8	1	1	3	13
Student recreational spaces	3	15	7	28	1	3	2	4	1	1	3.6429	14
Spaces exclusively for staff	0	0	7	28	2	6	4	8	5	5	2.6111	18
Spaces for parental interviews	0	0	3	12	5	15	2	4	1	1	2.9091	11
Library / Resource centre	1	5	8	32	4	12	2	4	0	0	3.5333	15
Classroom furniture	0	0	7	28	2	6	3	6	0	0	3.3333	12
Acoustics	0	0	4	16	4	12	0	0	2	2	3	10
											2.9296	

ICT for Administration — Prior to occupancy

ICT for Administration	5 Excellent		4 Good		3 Satisfactory		2 Poor		1 Unacceptable		Mar-09	Respondents
Quality of equipment	0	0	3	12	4	12	0	0	0	0	3.43	7
Speed of connections		0	3	12	3	9	1	2		0	3.29	7
Reliability		0	4	16	3	9		0		0	3.57	7
Range of software		0	4	16	2	6		0		0	3.67	6
Telephone System		0		0	4	12	3	6		0	2.67	7
Admin ICT Satisfaction											3.30	

ICT for Administration — Post Occupancy

ICT for Administration	5 Excellent		4 Good		3 Satisfactory		2 Poor		1 Unacceptable		Jul-09	Respondents
Quality of equipment	2	10	8	32	4	12	0	0	0	0	3.8671	14
Speed of connections		0	2	8	8	24	2	4		0	3	12
Reliability	2	10	4	16	4	12	4	8		0	3.2857	14
Range of software		0	8	32	4	12		0		0	3.6667	12
Telephone System		0		0	3	9	9	18	2	2	2.0714	14
											3.1762	

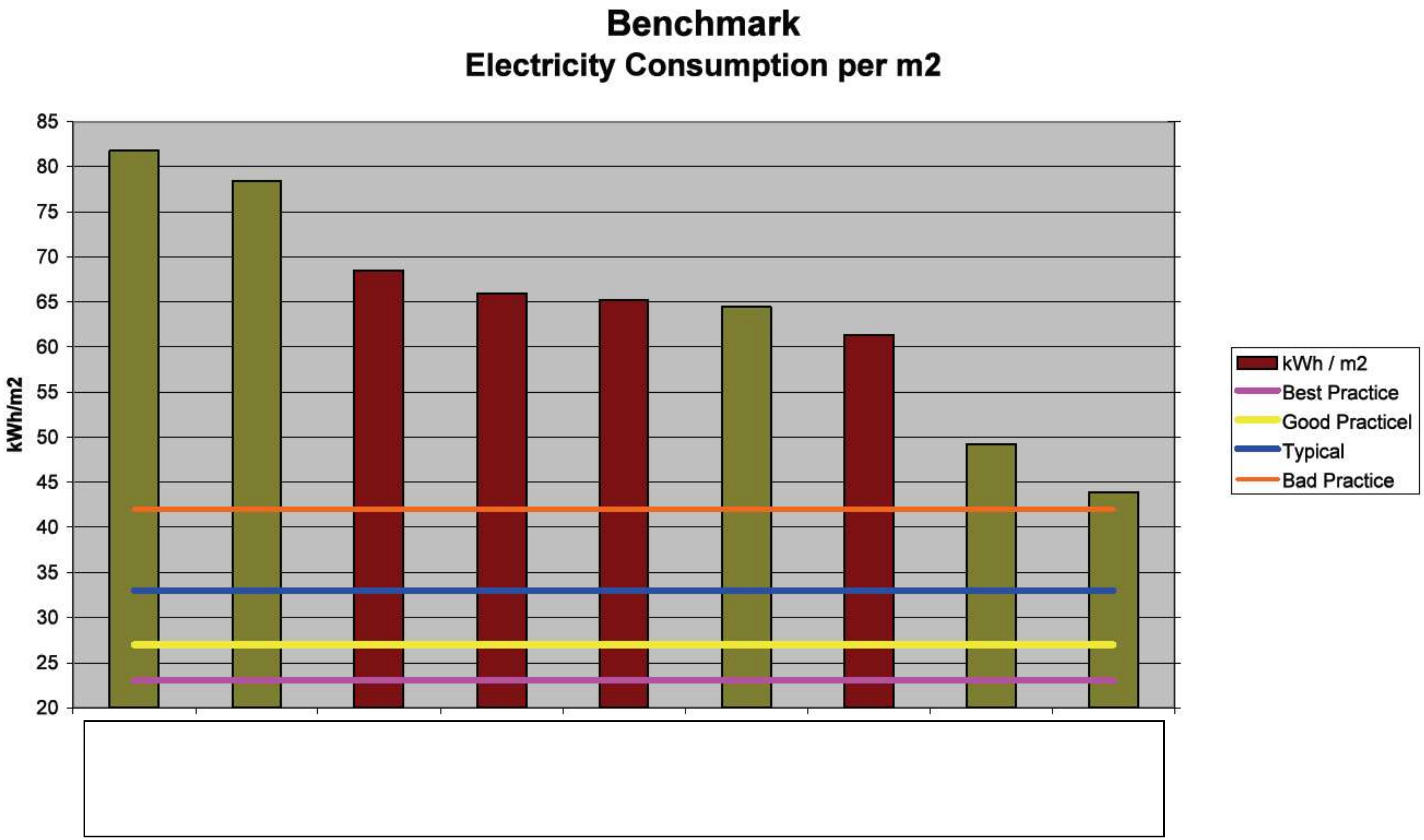
I find work.... — Prior to occupancy

I find work....	Never								Always		Mar-09	
Enjoyable	0	0	1	2	2	6	3	12	0	0	3.33	6
Exciting	1	1		0	2	6	3	12		0	3.17	6
Interesting		0	1	2	3	9	3	12		0	3.29	7
Stimulating	1	1		0	2	6	3	12		0	3.17	6
Challenging		0	1	4	2	6	3	6		0	2.67	6
Stressful	1	5	1	4	3	9	1	2		0	3.33	6
Frustrating		0	1	4	4	12	1	2		0	3.00	6
Boring		0	2	8	1	3	2	4	1	1	2.67	6
Admin staff satisfaction index											3.08	

I find work.... — Post Occupancy

I find work....	Never								Always		Jul-09	
Enjoyable	0	0	4	8	5	15	3	12	0	0	2.9167	12
Exciting	0	0	1	2	6	18	2	8	2	10	3.4546	11
Interesting	0	0	4	8	5	15	3	12	1	5	3.0769	13
Stimulating	0	0	4	8	4	12	4	16	1	5	3.1538	13
Challenging	3	15	2	8	5	15	1	2	1	1	3.4167	12
Stressful	5	25	2	8	5	15	1	2	0	0	3.8462	13
Frustrating	5	25	4	16	4	12	0	0	0	0	4.0769	13
Boring	1	5	1	4	3	9	2	4	3	3	2.5	10
											3.3052	

LA Half Hourly Electricity Analysis



FM Data

Monthly Submeter Consumption - School D

Submeter	Apr-09 kWh	May-09 kWh	Jun-09 kWh	Jul-09 kWh	Aug-09 kWh	Sep-09 kWh	Oct-09 kWh	Nov-09 kWh	Dec-09 kWh	Jan-10 kWh	Feb-10 kWh	Mar-10 kWh	Apr-10 kWh	May-10 kWh	Jun-10 kWh
DBEXT1LP Switch RM	0	0	0	30	726	716	2,303	2,545	2,768	2,646	2,065	2,183	1,588	1,161	6,334
DBEXT1Switch RM	0	0	0	0	0	0	0	0	0	-1,005	-4,688	-5,190	-5,023	-5,190	-4,521
DBF1LP 113	0	0	0	1,028	1,194	852	1,824	2,255	1,790	1,811	1,809	3,183	3,614	-1,120	9,910
DBF1PP 113	0	0	0	1,570	1,745	1,222	2,431	1,883	2,106	4,610	2,680	2,892	2,208	1,484	-1,894
DBF2LP 130	0	0	0	30	63	53	125	281	111	217	210	203	66	1,163	1,161
DBF2PP 130	0	0	0	62	1,582	1,561	3,112	3,728	1,899	4,340	3,132	3,158	2,230	-5,560	13,105
DBF3LPL 1st Staff Work RM05	896	577	504	1,818	619	485	919	1,091	414	1,213	967	9,187	65,437	31,742	3,586
DBF3LPP 1st Staff Work RM05	1,474	1,634	1,425	1,663	998	777	1,497	1,748	308	2,467	1,606	1,638	1,173	-8,221	4,981
DBF4LPL 1st Prep RM 14	1,698	2,015	1,712	1,766	1,161	966	1,800	2,217	951	2,375	1,889	285	-859	59,828	48,031
DBF4LPP 1st Prep RM 14	2,605	2,991	2,585	2,814	1,772	1,460	2,738	3,337	1,275	4,237	3,136	-4,935	-12,152	26,352	3,105
DBG10P Switch RM	0	0	0	1,748	1,460	878	1,582	1,815	1,182	1,637	1,763	1,843	1,354	1,876	-6,589
DBG6LPL GRD	11,166	3,447	2,595	4,396	3,170	1,852	3,934	4,100	867	1,911	6,020	5,686	2,518	5,069	7,520
DBG6LPP GRD	12,166	5,214	5,023	7,875	3,801	2,893	6,507	7,016	1,759	11,491	6,291	17,510	74,917	26,035	5,294
DBG7LPL GRD MAINT RM 27	4,331	5,558	6,114	7,048	618	2,127	2,253	1,733	1,938	11,982	4,147	4,222	2,921	6,455	65,751
DBG7LPP GRD MAINT RM 27	5,266	6,815	4,955	7,402	4,447	2,648	5,637	6,228	2,690	7,101	1,137	75	5,667	-77,951	74,378
DBG8P Switch RM	0	0	0	454	1,209	1,058	2,030	2,381	1,689	1,628	2,444	2,368	1,503	2,955	684
DBMCPLLG1 Switch RM	0	0	0	1,775	2,452	1,860	3,884	3,641	3,708	3,641	3,472	3,918	4,753	2,645	6,862
DBMCPS1	705	853	977	69,009	29,373	6,417	10,160	9,189	-16,808	-19,626	-17,726	-19,626	-18,993	-19,626	67,978
DBS1LP Switch RM	0	0	0	466	1,857	1,701	9,189	2,648	265	1,139	-8,765	-2,473	27,106	1,006	-34,139
DBS1LPL 01Rm13A	1,243	2,108	1,409	1,415	497	326	2,500	2,022	756	2,386	1,768	1,792	906	1,553	1,155
DBS1LPP 01Rm13A	2,809	5,471	3,528	2,959	803	532	6,060	4,517	1,355	6,048	4,374	4,252	3,008	5,828	7,870
DBS3LP Switch RM	0	0	1,045	2,124	1,314	2,231	4,917	5,265	4,603	5,151	4,821	5,236	4,636	-32	-41,310
DBS3LPL 2nd Staff Work RM23	744	833	737	702	511	426	841	1,093	415	1,092	866	869	540	84,014	1,011,050
DBS3LPP 2nd Staff Work RM23	3,940	4,262	4,003	5,963	3,074	2,173	4,798	5,154	1,520	7,946	4,697	4,362	3,182	10,124	39,400
LIFT Switch RM	0	0	0	9	47	44	43	55	35	2,880	13,278	7,892	-22,142	1,878	-1,921
MCP-S1 Switch RM	0	0	0	0	0	0	0	0	0	6,554	10,376	11,450	10,802	-158,273	68,350
Old Supply	3,935	12,633	9,013	3,776	14,323	13,861	32,036	24,643	27,556	14,091	10,350	13,131	21,123	78,474	395,769
Sports Hall Ele 1 Boiler RM	52,080	77,314	-12,238	-69,183	-841	-6,543	117,799	19,007	21,252	28,544	10,644	12,599	16,291	62,925	326,840
Sports Hall Ele 2 Boiler RM	-42,044	-58,125	9,948	43,851	26,550	17,700	-66,043	8,911	30,927	-15,857	7,702	10,464	19,875	-43,932	-410,126

Monthly Submeter Consumption - School C

Submeter	Apr-09 kWh	May-09 kWh	Jun-09 kWh	Jul-09 kWh	Aug-09 kWh	Sep-09 kWh	Oct-09 kWh	Nov-09 kWh	Dec-09 kWh	Jan-10 kWh	Feb-10 kWh	Mar-10 kWh	Apr-10 kWh	May-10 kWh	Jun-10 kWh
MCP-S1 Boiler Rm	0	0	0	8	60	43	52	47	11	13	14	27	36	88	-624
DB EXT4 Boiler Rm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sprinkler Boiler Rm	0	0	0	0	1	0	1	2	1	2	3	1	1	21	1,457
DB LG1 Light Boiler Rm	0	0	0	22	169	173	143	141	173	131	120	167	122	175	61
DB LG1 Power Boiler Rm	0	0	0	23	182	187	158	155	186	146	133	179	127	187	66
MCP LG1 Boiler Rm	0	0	594	4,454	3,451	3,285	3,816	4,052	5,381	6,633	6,392	5,557	3,803	3,805	1,353
DB EXT1 Boiler Room	0	0	0	0	0	0	0	0	0	0	0	66	396	637	115
DB EXT1 LP Boiler Rm	0	0	0	0	0	125	772	748	1,062	639	723	622	436	560	0
DB G7 LP	0	0	0	0	0	606	3,838	4,131	2,712	3,311	2,931	3,216	2,221	4,011	0
SB LG1 Boiler Rm	0	0	0	1	5	12	17	23	12	22	19	2	2	-7,069	5,896
DB G11 Boiler Rm	0	0	0	112	866	2,184	2,707	2,985	2,047	2,972	2,492	2,996	1,606	6,762	-1,886
DB F1 LP Boiler Rm	0	0	0	0	0	2,936	3,395	3,674	2,587	3,752	3,016	3,348	1,933	3,839	0
SB F1 Boiler Rm	0	0	3,134	23,028	14,546	24,591	26,150	27,552	22,527	29,988	27,380	27,730	16,606	32,145	12,948
DB G11 Power Kitchen	0	0	0	149	1,154	2,329	2,723	2,342	2,004	4,134	2,603	3,184	1,699	3,701	1,326
DB G12 Power PE Staff Rm	0	0	0	0	0	0	0	0	0	2,224	15,571	3,029	39	5,018	1,197
DB LG2 Light LG026	0	0	384	2,674	637	4,383	3,818	4,845	3,031	4,531	4,058	4,714	2,663	3,920	1,814
DB LG2 Power LG026	0	0	0	179	1,387	3,911	4,829	5,133	2,700	5,339	4,321	5,508	2,310	4,237	1,950
MCP LG2 LG026	0	0	0	6	48	65	52	41	53	51	45	45	33	57	25
DB EXT3 LG026	0	0	0	6	45	65	79	77	496	662	1,157	754	440	3	0
Maths Main LG026	0	0	0	13	104	148	158	170	119	152	132	152	92	177	66
DB G7 Light G046	0	0	0	312	2,419	2,763	3,448	1,944	2,159	3,543	6,679	972	1,714	3,650	1,723
DB G7 Power G046	0	0	0	358	2,773	3,802	3,089	2,380	2,738	4,265	6,823	1,670	1,226	4,040	2,041
DB G8 Light CSU	0	0	0	466	3,611	3,910	3,973	3,838	2,283	3,282	4,866	3,987	3,046	4,509	-303
DB G8 Power CSU	0	0	0	435	3,372	5,227	5,601	5,740	3,187	4,664	7,607	5,925	3,019	21,258	82,474
DB F3 Light AR2	0	0	0	132	1,021	2,123	2,229	2,371	1,238	3,027	2,151	2,351	1,420	2,655	1,108
DB F3 Power AR2	0	0	0	151	1,167	2,316	2,751	3,092	1,437	3,598	2,642	2,896	1,743	3,276	1,402
DB G9 Light G005	0	0	0	73	565	852	1,221	1,390	640	1,778	1,201	1,238	693	1,236	482
DB G9 Power G005	0	0	0	100	776	1,417	1,805	2,014	894	2,686	1,840	1,967	1,071	2,078	823
DB F6 Power E10	0	0	0	19	146	1,420	879	1,825	989	1,236	1,024	1,014	1,018	2,159	872
DBF5 Power ICT	0	0	0	338	2,616	2,373	2,229	4,550	1,844	4,289	2,952	3,104	2,295	3,898	1,607
DB EXT2 G014	0	0	0	0	0	0	0	0	0	301	2,105	437	485	54,914	46,999
DB G1 Light G053	0	0	0	200	1,553	2,733	2,706	3,157	1,719	3,967	3,018	3,172	1,838	3,476	1,254
DB G1 Power G053	0	0	0	247	1,916	3,318	3,873	4,324	2,107	5,364	4,000	4,356	2,537	5,077	1,728
DB F2 Light MU1	0	0	0	109	841	1,036	1,215	1,275	1,001	1,304	947	920	519	1,949	866
DB F2 Power MU1	0	0	0	111	861	2,071	1,979	1,987	1,057	1,625	2,387	1,668	921	2,877	1,176
DB F1 Light F34A	0	0	158	1,150	649	1,629	2,692	2,531	1,143	3,094	2,111	2,276	1,164	2,362	910
DB F1 Power F34A	0	0	0	181	1,405	3,148	3,420	3,689	1,896	2,777	4,701	3,446	1,947	3,764	1,467
DB G10 Light G080	0	0	0	175	1,354	2,529	2,655	2,815	1,777	3,042	2,382	2,435	1,383	2,567	959
DB G10 Power G080	0	0	0	157	1,220	3,086	3,298	3,464	2,049	3,840	2,927	3,063	1,662	3,143	1,481
DB F4 Light F064	0	0	0	159	1,230	2,119	2,348	2,505	1,470	3,124	2,290	2,613	1,325	2,718	1,023
DB F4 Power G080	0	0	0	181	1,404	3,700	3,432	3,596	1,873	4,715	3,020	3,343	3,235	3,343	1,714
DB S1 Light	0	0	0	164	1,268	1,736	1,874	2,196	1,290	3,874	2,411	2,417	1,691	2,782	1,040
DBS2 Power	0	0	0	195	1,511	1,977	2,714	2,773	1,370	4,806	2,926	3,003	2,038	3,500	1,300
SB LG1 LG026	0	0	0	0	0	18	17	23	9	24	9	11	2	3	0
DB EXT4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DB F4 Power F064	0	0	0	0	0	0	0	0	0	0	0	3,557	2,050	4,272	0

Monthly Submeter Consumption - School A

Submeter	Apr-09 kWh	May-09 kWh	Jun-09 kWh	Jul-09 kWh	Aug-09 kWh	Sep-09 kWh	Oct-09 kWh	Nov-09 kWh	Dec-09 kWh	Jan-10 kWh	Feb-10 kWh	Mar-10 kWh	Apr-10 kWh	May-10 kWh	Jun-10 kWh
DBG MP3 LP1 Grnd Stair Plnt	0	682	1,697	1,430	628	1,656	1,769	1,712	1,407	1,979	1,732	1,858	0	0	0
DBG MP3 LP2 Grnd Stair Plnt	0	826	2,070	2,204	1,429	2,077	2,357	2,281	2,045	2,564	2,979	1,381	0	0	0
DBG MP3 EX1 Grnd Stair Plnt	0	0	0	10	0	26	158	153	404	392	325	306	0	0	0
DBF MP3 LP1 Grnd Stair Plnt	0	143	352	228	172	351	353	342	271	377	345	409	0	0	0
DBF MP3 LP2 Grnd Stair Plnt	0	643	1,598	1,315	981	1,509	1,640	1,587	1,401	594	2,500	1,637	0	0	0
DBS MP3 LP1 Grnd Stair Plnt	0	302	747	497	210	829	889	860	652	909	758	957	0	0	0
MP3 2 Grnd Stair Plnt	0	2,350	5,864	5,432	3,508	5,698	7,045	6,818	6,614	9,987	9,134	9,089	0	0	0
MP3 1 Grnd Stair Plnt	0	415	1,023	588	215	1,385	1,417	1,371	1,193	1,642	1,311	1,531	0	0	0
DBS MP3 LP2 Grnd Stair Plnt	0	540	1,340	1,042	668	1,543	1,764	1,707	1,694	2,011	1,753	2,012	0	0	0
DBG MP3 LP1 Grnd Stair Plnt	0	682	1,697	1,430	628	1,656	1,769	1,712	1,407	1,979	1,732	1,858	0	0	0
DBG MP3 LP2 Grnd Stair Plnt	0	826	2,070	2,204	1,429	2,077	2,357	2,281	2,045	2,564	2,979	1,381	0	0	0
DBG MP3 EX1 Grnd Stair Plnt	0	0	0	10	0	26	158	153	404	392	325	306	0	0	0
DBF MP3 LP1 Grnd Stair Plnt	0	143	352	228	172	351	353	342	271	377	345	409	0	0	0
DBF MP3 LP2 Grnd Stair Plnt	0	643	1,598	1,315	981	1,509	1,640	1,587	1,401	594	2,500	1,637	0	0	0
DBS MP3 LP1 Grnd Stair Plnt	0	302	747	497	210	829	889	860	652	909	758	957	0	0	0
MP3 2 Grnd Stair Plnt	0	2,350	5,864	5,432	3,508	5,698	7,045	6,818	6,614	9,987	9,134	9,089	0	0	0
MP3 1 Grnd Stair Plnt	0	415	1,023	588	215	1,385	1,417	1,371	1,193	1,642	1,311	1,531	0	0	0
DBS MP3 LP2 Grnd Stair Plnt	0	540	1,340	1,042	668	1,543	1,764	1,707	1,694	2,011	1,753	2,012	0	0	0
DBG MP1 SLP1 G26	0	29	73	103	104	111	187	181	90	1,862	795	504	0	0	0
DBG MP1 EX1 G26	0	0	2	61	87	216	550	532	2,102	2,054	1,699	1,593	0	0	0
Mains Water Booster G26	0	51	128	111	76	150	153	148	117	161	155	167	0	0	0
MP2 G26	0	733	5,252	95,418	11,181	27,866	14,480	14,013	19,012	24,239	20,234	22,120	0	0	0
MP3 G26	0	6,539	16,399	17,163	8,356	17,950	19,135	18,518	17,345	24,077	20,635	22,112	0	0	0
MP1 1 G26	0	241	593	280	53	590	637	616	447	648	603	730	0	0	0
DBG MP1 LP1 G26	0	1,192	2,951	2,144	1,572	3,051	3,053	2,955	2,679	3,747	8,891	51,903	0	0	0
DBG MP1 LP2 G26	0	1,471	3,666	3,361	2,590	4,377	4,752	4,599	4,470	5,308	4,545	5,002	0	0	0
DBFMP1 LP1 G26	0	238	594	591	490	890	1,022	989	995	1,115	905	963	0	0	0
DBF MP1 LP2 G26	0	551	1,374	1,241	851	1,345	1,363	1,319	1,103	1,374	1,251	1,294	0	0	0
DBS MP1 LP1 G26	0	198	490	380	220	628	741	717	580	812	663	797	0	0	0
DBS MP1 LP2 G26	0	609	1,515	1,323	1,052	1,707	1,811	1,753	1,416	1,920	1,721	1,986	0	0	0
DBG Mech Control Panel G26	0	752	2,017	5,649	1,876	3,908	1,959	1,896	1,632	3,186	1,639	1,801	0	0	0
DBG MP1 LP1 G32	0	35	86	47	7	53	88	86	75	103	78	126	0	0	0
DBG MP1 LP2 G32	0	25	62	40	17	40	56	54	46	68	77	90	0	0	0
DBG MP1 1 LP3 G32	0	2	4	6	0	3	6	5	13	21	21	10	0	0	0
DBG MP1 1 LP4 G32	0	167	410	174	3	473	460	445	293	428	389	474	0	0	0
Mech Control Panel G11B	0	201	1,705	33,259	2,712	4,996	4,978	4,817	5,725	8,424	6,170	6,380	0	0	0
Main Hall Stage Lighting G11B	0	12	30	-2	7	35	70	68	50	35	30	45	0	0	0
DBG MP2 LP1 G11B	0	1,185	2,939	2,184	1,256	3,310	3,183	3,081	2,557	3,425	2,922	3,550	0	0	0
DBG MP2 LP3 G11B	0	1,097	2,705	1,611	1,219	1,903	1,847	1,787	1,460	1,957	1,811	2,044	0	0	0
DBF MP2 LP2 G11B	0	193	481	421	227	503	499	483	380	527	447	514	0	0	0
DBF MP2 LP3 G11B	0	738	1,836	1,542	884	1,811	1,911	1,850	1,623	2,143	1,991	2,071	0	0	0
DBF MP2 LP4 G11B	0	1,199	3,013	3,544	3,387	2,929	3,213	3,110	3,199	3,215	2,958	3,232	0	0	0
DBG MP2 EX1 G11B	0	2	5	9	16	40	95	92	129	124	103	95	0	0	0
DBG MP3 2 EX2 Spts Hall Plnt Rm	0	1	880	23,715	2	3,201	19,835	19,195	642	15	93	169	0	0	0
DBG MP3 2 EX1 Spts Hall Plnt Rm	0	67	161	43	322	496	1	1	2,392	4,575	4,322	5,883	0	0	0
DBG MP3 2 Mech Con Panel Spts Hall	0	2,286	5,534	1,282	7,815	9,969	691	669	11,238	17,862	14,188	17,693	0	0	0
DBG MP3 2 LP1 Spts Hall Plnt Rm	0	6,070	14,982	11,573	24,259	33,362	5,270	5,100	40,600	29,649	53,642	68,579	0	0	0

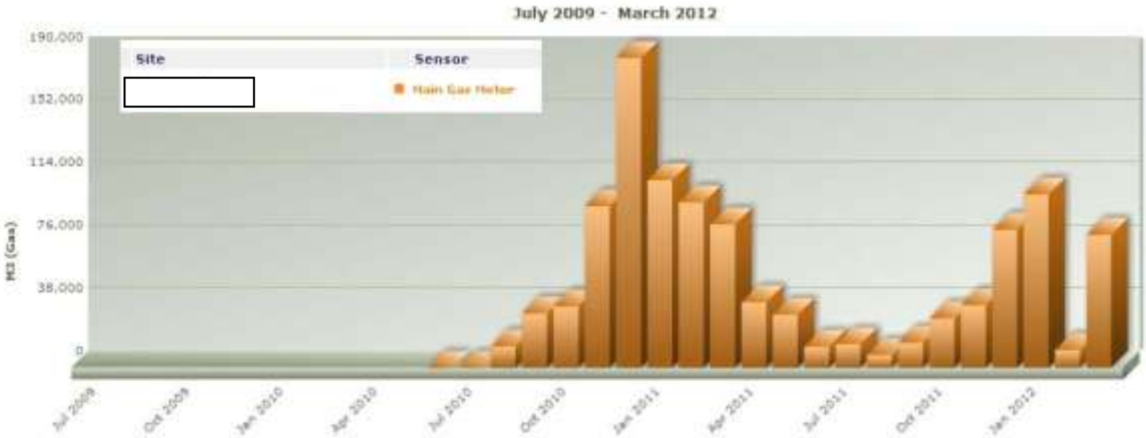
Monthly Submeter Consumption - School B

Submeter	Apr-09 kWh	May-09 kWh	Jun-09 kWh	Jul-09 kWh	Aug-09 kWh	Sep-09 kWh	Oct-09 kWh	Nov-09 kWh	Dec-09 kWh	Jan-10 kWh	Feb-10 kWh	Mar-10 kWh	Apr-10 kWh	May-10 kWh	Jun-10 kWh
Plant Room MCC G22 Switch Room	0	0	0	4,380	11,007	3,985	5,090	4,702	5,844	6,082	5,946	3,264	6,073	-381	1,255
Roof Plant MCC F_005A Switch Room	0	0	0	4,019	4,082	4,623	4,555	5,079	5,640	6,202	6,668	4,030	7,022	-1,170	3,886
DB FF AC1 F005A Switch Room	0	0	0	2,488	612	1,428	1,501	520	278	322	374	115	584	1,292	723
DB FF Sports F-010 Switch Room	0	0	0	1,040	1,263	1,667	1,719	2,188	1,669	1,839	1,984	1,198	1,979	-207	685
DB GF Sports G-018B Switch Room	0	0	0	2,615	2,533	3,430	4,376	5,280	3,385	4,369	5,812	3,722	5,881	-328	1,569
DB FF Plant G025 Switch Room	0	0	0	461	402	348	315	342	318	394	499	262	472	-59	200
DB GF Hall Drama G34	0	0	0	807	1,054	1,451	1,719	1,799	1,238	43,091	118,307	-156,967	1,709	-368	539
DB GF Music Dept G34	0	0	0	1,531	1,618	2,106	2,396	2,766	104,914	26,733	-124,144	1,814	3,166	-405	1,303
DB SF Lab 1 Science Lab 1 G34	0	0	0	118	101	211	258	321	202	240	290	194	332	-37	131
DB SF Lab 2 Science Lab 2 G34	0	0	0	81	80	156	187	242	135	170	222	149	221	-32	92
DB SF Lab 3 Science Lab 3 G34	0	0	0	114	83	189	223	319	191	236	300	200	308	-51	129
Stage Lighting Supply G34	0	0	0	14	82	392	521	941	213	1,695	4,341	5,434	736	-123	187
AHU2 G34	0	0	0	4,804	7,669	4,196	3,483	3,322	9,042	7,993	5,229	2,065	2,949	-696	2,304
DB GF Art G34	0	0	0	752	766	1,182	1,109	-1,527	4,040	3,400	1,859	1,148	1,776	-204	700
DB GF Maths 1 Maths Dept G34	0	0	0	1,201	1,298	1,700	1,945	2,358	7,684	6,060	2,393	1,433	2,349	-279	957
DB GF Maths 2 Maths Dept G34	0	0	0	370	308	788	1,381	7,487	-3,074	-1,028	2,953	8,390	1,145	-139	436
DB SF LP1 Science G34	0	0	0	1,206	1,311	1,449	1,377	1,625	-5,976	-325	10,427	1,040	1,760	-211	724
DB GF Dining Hall G34	0	0	0	426	604	669	722	1,129	631	790	1,016	555	933	-147	324
DB SF Lab 4 Science 4 G34	0	0	0	134	129	178	204	274	170	214	277	183	334	-43	137
DB SF Lab 5 Science 5 G34	0	0	0	82	73	158	188	269	172	198	229	147	221	-35	95
DB SF Lab 6 Science 6 G34	0	0	0	72	75	149	183	228	162	197	244	145	218	-26	81
DB GF Hum 1 Humanities Dept G34	0	0	0	2,003	2,064	2,737	3,049	3,538	2,460	2,975	3,664	2,211	-1,199	-22,447	-1,686
DB GF Hum 2 Humanities Dept G53	0	0	0	1,138	1,085	1,668	1,920	2,408	1,720	2,061	2,507	1,470	2,429	-251	921
DB SF Lab 7 Science Lab 7 G53	0	0	0	82	86	178	200	240	165	198	242	153	222	-31	90
DB SF Lab 8 Science Lab 8 G53	0	0	0	91	83	165	213	282	161	198	248	161	222	-21	69
DB SF Lab 9 Science Lab 9 G53	0	0	0	80	80	182	245	270	162	208	277	129	173	-31	67
AHU 3 G53	0	0	0	18,451	-10,126	2,519	2,724	4,728	8,230	8,353	7,778	4,018	6,013	-652	3,229
DB FF Eng 1 English Dept G53	0	0	0	1,778	1,708	2,334	2,708	3,447	2,535	2,942	3,429	1,978	3,128	-381	1,177
DB FF Eng 2 English Dept G53	0	0	0	658	641	1,007	1,192	2,124	778	1,097	1,596	863	1,328	-158	536
DB GF Admin Dept G53	0	0	0	727	557	1,052	1,201	1,808	1,122	1,357	1,672	932	1,460	-212	619
DB SF LP2 General Science G53	0	0	0	-3,737	5,843	1,252	1,455	1,821	1,138	1,343	1,603	1,117	1,846	-198	679
DB SF Lab 10 Science Lab 10 G53	0	0	0	71	65	183	238	295	187	211	235	116	227	-37	80
DB GF RM1 Resistant Material G53	0	0	0	155	112	258	287	405	-722	-457	89	2,296	363	-44	135
DB GF RM2 Resistant Material G53	0	0	0	104	86	229	252	364	444	438	384	-188	297	-34	136
DB GF Food 1 Food Technology G69	0	0	0	241	201	407	575	741	-472	-194	354	2,284	631	-99	279
DB GF Food 2 Food Technology G69	0	0	0	268	202	403	583	727	444	535	657	272	452	-128	294
DB GF Admin Dept G69	0	0	0	727	675	1,148	1,306	1,699	3,268	2,443	643	8,628	1,245	130,833	539
DB GF Tex 1 Textiles G69	0	0	0	87	47	194	227	252	5,211	4,064	1,494	-9,952	251	-36	119
DB GF Tex2 Textiles G69	0	0	0	62	18	54	76	114	477	416	259	-607	389	-465	37
AHU4 G69	0	0	0	2,713	2,414	2,079	3,312	7,932	-14,586	-9,840	115	39,037	3,352	-511	1,910
DB GF DTGen Design Tech G69	0	0	0	1,811	1,755	2,141	2,247	2,738	8,701	7,384	4,171	-11,117	3,112	-335	1,221
DB GF ICT Dept G69	0	0	0	2,912	2,213	4,249	4,945	6,282	-5,081	-2,418	2,869	25,915	6,546	-674	2,351
DB FF Languages Dept G69	0	0	0	1,165	893	1,364	1,568	1,822	15,720	13,009	6,609	-29,740	1,642	121,068	56,290
DB GF MW1 Metal Work G69	0	0	0	84	42	71	78	89	7,532	5,966	2,418	-15,625	93	-11	40
DB GF Cam 1 Cam Room	0	0	0	98	1,721	6,556	2,092	278	-303	-173	91	1,031	215	-52	99
DB GF LSU Learning Support G69	0	0	0	722	589	1,144	911	1,472	4,952	-272	-10,155	10,687	1,277	-187	521
DB GF Comms Comms Rm G69	0	0	0	2,347	2,536	2,512	1,610	-12,136	4,442	3,648	1,789	18,131	4,341	-555	1,874
DB FF Plant F005A Switch Room	0	0	0	35	29	68	124	105	21	37	63	13	29	-9	33
DB GF Kitchen G009A	0	0	0	1,617	1,449	2,762	2,948	3,459	2,194	2,585	3,075	2,126	3,528	-742	1,847
Existing Sub Main Meter	0	0	0	0	0	0	0	0	625	147	-773	520	119	-10	40
Football Pitch Lighting	0	0	0	0	0	0	0	0	44	-50	-225	554	42	-1	11
Changing Room	0	0	0	0	0	0	0	0	22	-23	-107	224	40	-4	15
Netball Court	0	0	0	0	0	0	0	0	165	224	315	900	19	0	7
Grp Substation	0	0	0	0	0	0	0	0	6	-6	-29	44	3	0	1
Boundary DB Ele	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trace Heating	0	0	0	0	0	0	0	0	7	2	-8	23	1	0	0
Vehicle Gate	0	0	0	0	0	0	0	0	0	0	0	6	7	1	4
Pedestrian Gate	0	0	0	0	0	0	0	0	1	1	1	12	2	0	0
PV Electric	0	0	0	0	0	0	0	0	0	0	0	0	0	-16	28

Biomass Consumption at School B – IMAT 2 Online Data Base

Water Consumption at School D – IMAT 2 Data Base

The data generated from the online data base did not correspond with metered data.



Biomass Delivery Data

Site and Data Set Details Report for the period 01/01/2009 to 31/12/2011

Name	Code	Utility	Delivery Date	Quantity delivered (tonnes)
School C	IS 009	Solid Fuel	6/3/2009	167
	IS 009	Solid Fuel	6/10/2009	169
	IS 009	Solid Fuel	3/1/2010	77
	IS 009	Solid Fuel	3/5/2010	103
	IS 009	Solid Fuel	3/12/2010	113
	IS 009	Solid Fuel	3/22/2010	103
	IS 009	Solid Fuel	4/8/2010	108
	IS 009	Solid Fuel	4/23/2010	92
	IS 009	Solid Fuel	4/30/2010	89
	IS 009	Solid Fuel	5/7/2010	102
	IS 009	Solid Fuel	1/18/2011	108
	IS 009	Solid Fuel	2/11/2011	112
	IS 009	Solid Fuel	11/24/2011	95
School B	IS 057	Solid Fuel	4/22/2009	81
	IS 057	Solid Fuel	6/1/2009	84
	IS 057	Solid Fuel	6/17/2009	75
	IS 057	Solid Fuel	7/8/2009	90
	IS 057	Solid Fuel	10/20/2009	96
	IS 057	Solid Fuel	1/21/2010	101
	IS 057	Solid Fuel	2/4/2010	100
	IS 057	Solid Fuel	2/24/2010	81
	IS 057	Solid Fuel	4/1/2010	114
	IS 057	Solid Fuel	4/21/2010	103
	IS 057	Solid Fuel	5/25/2010	57
	IS 057	Solid Fuel	1/13/2011	88
	IS 057	Solid Fuel	2/3/2011	103
	IS 057	Solid Fuel	3/28/2011	104
	IS 057	Solid Fuel	9/22/2011	104
	IS 057	Solid Fuel	11/21/2011	95
TOTAL : 29 items				2915

This delivery data was not correct since the storage capacity was 20t and 10t

Biomass Meter Reading Data

Site and Data Set Details Report for the period 01/01/2009 to 31/12/2011

Name	Code	Utility	Reading Date	Reading (MWh)
School C	IS 009	Heating_Energy	12/15/2011	59
	IS 009	Heating_Energy	2/28/2010	19
	IS 009	Heating_Energy	3/31/2010	19
School B	IS 057	Heating_Energy	1/31/2011	204
	IS 057	Heating_Energy	12/31/2010	166
	IS 057	Heating_Energy	11/30/2010	166
	IS 057	Heating_Energy	10/31/2010	166
	IS 057	Heating_Energy	9/30/2010	166
	IS 057	Heating_Energy	8/31/2010	166
	IS 057	Heating_Energy	5/31/2010	165
	IS 057	Heating_Energy	4/30/2010	152
	IS 057	Heating_Energy	3/31/2010	116
	IS 057	Heating_Energy	2/28/2010	108
	IS 057	Heating_Energy	10/31/2011	254
	IS 057	Heating_Energy	9/30/2011	239
	IS 057	Heating_Energy	8/31/2011	238
	IS 057	Heating_Energy	7/31/2011	238
	IS 057	Heating_Energy	6/30/2011	238
	IS 057	Heating_Energy	5/31/2011	238
	IS 057	Heating_Energy	4/30/2011	238
	IS 057	Heating_Energy	12/31/2011	288
	IS 057	Heating_Energy	11/30/2011	275
	IS 057	Heating_Energy	7/31/2010	166
	IS 057	Heating_Energy	2/28/2011	215
	IS 057	Heating_Energy	3/31/2011	215
	IS 057	Heating_Energy	6/30/2010	166
TOTAL : 26 items				

When these figures were compared with the delivery data from English Wood Fuels they did not correspond

List of questions designed to instigate dialogue with participants

Procurement Questions (practitioners):

- How important was energy efficiency in developing the brief/output specification?
- How would you describe relations throughout the bidding and design phase?
- What safeguards were in place to protect each party from various types of project risk?
- Do the post-occupancy arrangements promote energy efficiency?

The BSF Process (governors):

- How much involvement did you have with the BSF process?
- Do you feel that this was enough involvement?
- Were you consulted on the overall vision that the school wanted to achieve?
- How much involvement did you have with the design and development phases of the BSF process?

The New Schools:

- What were the key expectations or requirements of the new school?
- Do you think the final design solution has met these expectations?
- What areas do you think have been particularly successful?
- What areas do you think could still be improved?
- What don't you like about the new school?
- Is the school exciting and inspirational for teachers and pupils?
- How was the "transformation" interpreted in relation to the design and vision?
- What impact do you think the new schools will have on their staff, teachers and pupils?

Environmental Aspects:

- How significant was the aim of achieving a zero carbon school?
- What environmental features have been incorporated into the design of the school?
- From an environmental perspective do you think the schools are as energy efficient as it can be given the limitations such as site and budget?
- What additional environmental features would you like to see?
- How do you think that sustainable development and the inclusion of environmental features can be more successfully achieved within the next phase of BSF?
- Who do you think the responsibility of achieving a zero carbon school lies with?

Questions for Business Managers

- Has the new school been as good as you thought it would be?
- What were the failings of the old school?
- Were you involved in the design of the new school?
- Is there anything you would change about the new school design?
- Has the BSF process been well managed?
- If there was more money what else do you think would improve the school?
- Do you think your school represents a Low-Energy Design?
- What in your view will be the legacy/impact of BSF? Should we be prioritising?
- In your view, speaking to the staff and pupils is the school having a positive impact on the wider community?

Definitions

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Further details:

BUS job number 1128

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Building Use Studies Ltd.,
c/o Sprunt,
The Quadrangle,
180 Wardour Street,
London W1F 8FY
UK

Licence agreement

28/9/10

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Adrian Leaman, Building Use Studies — *The Licensor*

and:

Michael Roberts, Institute of Energy and Sustainable Development, De Montfort University — *The Licensee*

concerning the method/s:

BUS Methodology 2-page occupant questionnaire 2010 Workplace with Response version

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More details are available of the approach on:
www.usablebuildings.co.uk/WebGuideOSM/index.html

Signed: A Leaman

Digitally signed by A Leaman
DN: cn=A Leaman, o=Arup, ou=Building Performance and Research, email=adrian.leaman@arup.com, c=GB
Date: 2010.09.28 09:33:30 +01'00'

Adrian Leaman, Building Use Studies

Signed:

Michael Roberts, Institute of Energy and Sustainable Development, De Montfort University

VAT number: (GB) 371 1084 78		Company number	1497266
Account Name:	Building Use Studies Limited		
Account No:	20207543		
Bank Address:	Barclays Bank, Barclays Business Centre, P O Box 32016, London NW1 2ZH		
Bank Sort Code:	20-03-53	Swift code:	BARCGB22

BUS note to Participants

Disclosure

This questionnaire has been designed and developed by the Useable Buildings Trust so that the results can be **validated** across a national database.

If any questions are unclear or inappropriate do not feel you must answer them.

If you would like to provide any feedback about the questionnaire in terms of appropriateness, ambiguity, style or format, please do not hesitate to contact me via email at mroberts@dmu.ac.uk

Thank you for taking the time to complete this questionnaire.

With kind regards,

Michael D Roberts

Building Evaluation

This survey is being conducted to help with future planning and design of buildings. The information collected will be treated as completely confidential by the survey team. Survey reports will use summaries of information and not reveal the identities of individuals.

Please answer for the study building only. Please fill in as many questions as you can. Write any further comments in the spaces provided or on a separate sheet.

Thank you for your help

Queries:
If you have any queries please contact Michael Roberts
Email: Michael Roberts <mroberts@dmu.ac.uk>

Background

Please note: We ask about age and sex because these are both relevant to people's needs in buildings. We ask for names so that we can follow up any matters that may arise.

What is your age …? *Please tick* Under 30 [1] [2] 30 or over

… and your sex? *Please tick* Male [1] [2] Female

Please give your name … *Surname, then first name (at your discretion)*

… and Department *Department*

Is this building your normal base? *Please tick* Yes [1] [2] No

If No, which is … ? *Normal base if not this building*

Please tick if you are an outside contractor *Contractor* [1]

Is your office or work area …? *Please tick*
Normally occupied by you alone [1]
Shared with 1 other [2]
Shared with 2-4 others [3]
Shared with 5-8 others [4]
Shared with more than 8 others [5]

Do you sit next to a window at your normal workspace? *Please tick* Yes [1] [2] No

How long have you worked in this building? *Please tick* Less than a year [1] [2] A year or more

How long have you worked in your present work area? *Please tick* Less than a year [1] [2] A year or more

How many days do you spend in the building in a normal working week? *Days per week in building*

How many hours per day do you spend in the building on a normal working day? *Hours per day in building*

How many hours per day do you spend at your desk or normal work area on a normal working day? *Hours per day at desk*

How many hours per day do you normally spend working with a computer screen (VDU)? *Hours per day at VDU*

The building overall

Building design All things considered, how do you rate the building design overall? *Please tick*
Unsatisfactory [1] [2] [3] [4] [5] [6] [7] Satisfactory

Comments about design overall

Needs In the building as a whole, do the facilities meet your needs? *Please tick*
Unsatisfactory [1] [2] [3] [4] [5] [6] [7] Satisfactory

Comments about needs overall

Space In the building as a whole, do you think that space is used …? *Please tick*
Ineffectively overall [1] [2] [3] [4] [5] [6] [7] Effectively overall

Image How do you rate the image that the building as a whole presents to visitors…? *Please tick*
Poor [1] [2] [3] [4] [5] [6] [7] Good

Safety How do you rate your personal safety in and around the building …? *Please tick*
Poor [1] [2] [3] [4] [5] [6] [7] Good

Cleaning How do you rate the cleaning …? *Please tick*
Unsatisfactory [1] [2] [3] [4] [5] [6] [7] Satisfactory

Availability of meeting rooms *Please tick*
Unsatisfactory [1] [2] [3] [4] [5] [6] [7] Satisfactory

Comments about meeting rooms

Suitability of storage arrangements *Please tick*
Unsatisfactory [1] [2] [3] [4] [5] [6] [7] Satisfactory

Comments about storage

Your work

Please briefly describe the work that you carry out in this building …?

Work description

Your work requirements

Specifically, for the work that you carry out, how well do the facilities meet your needs …? *Please tick*
Very poorly [1] [2] [3] [4] [5] [6] [7] Very well

Please give examples of things which can hinder effective working …?

Hinder

… and examples of things which usually work well …?

Work well

Your desk or work area

Furniture How do you rate the usability of the furniture provided at your desk or normal work area …? *Please tick*
Very poor [1] [2] [3] [4] [5] [6] [7] Very good

Space at desk Do you have enough space at your desk or normal work area …? *Please tick*
Too little [1] [2] [3] [4] [5] [6] [7] Too much

Comments about your desk or work area

Comfort

This section asks how comfortable you find the building in both winter and summer.

How would you describe typical working conditions in your normal work area in WINTER? If you have not worked here in winter then please leave these questions blank and just complete the questions on Temperature in Summer

Temperature in winter

Please tick your rating on each scale

Uncomfortable	1	2	3	4	5	6	7	Comfortable
Too hot	1	2	3	4	5	6	7	Too cold
Stable	1	2	3	4	5	6	7	Varies during the day

Air in winter

Still	1	2	3	4	5	6	7	Draughty
Dry	1	2	3	4	5	6	7	Humid
Fresh	1	2	3	4	5	6	7	Stuffy
Odourless	1	2	3	4	5	6	7	Smelly

Conditions in winter

Unsatisfactory overall	1	2	3	4	5	6	7	Satisfactory overall

How would you describe typical working conditions in your normal work area in SUMMER? If you have not worked here in summer then please leave these questions blank and just complete the questions on Temperature in Winter

Temperature in summer

Please tick your rating on each scale

Uncomfortable	1	2	3	4	5	6	7	Comfortable
Too hot	1	2	3	4	5	6	7	Too cold
Stable	1	2	3	4	5	6	7	Varies during the day

Air in summer

Still	1	2	3	4	5	6	7	Draughty
Dry	1	2	3	4	5	6	7	Humid
Fresh	1	2	3	4	5	6	7	Stuffy
Odourless	1	2	3	4	5	6	7	Smelly

Conditions in summer

Unsatisfactory overall	1	2	3	4	5	6	7	Satisfactory overall

Noise

How would you describe noise in your normal work area?
This question refers to conditions all year round

Please tick your rating on each scale

Noise overall	Unsatisfactory	1	2	3	4	5	6	7	Satisfactory
Noise from colleagues	Too little	1	2	3	4	5	6	7	Too much
Noise from other people	Too little	1	2	3	4	5	6	7	Too much
Other noise from inside	Too little	1	2	3	4	5	6	7	Too much
Noise from outside	Too little	1	2	3	4	5	6	7	Too much

Please estimate how you are affected by unwanted interruptions …

Unwanted interruptions	Not at all	1	2	3	4	5	6	7	Very frequently

Comments about noise and its sources

Lighting

How would you describe the quality of the lighting in your normal work area? *This question refers to conditions all year round*

Please tick your rating on each scale

Lighting overall	Unsatisfactory	1	2	3	4	5	6	7	Satisfactory
Natural light	Too little	1	2	3	4	5	6	7	Too much
Glare from sun and sky	None	1	2	3	4	5	6	7	Too much
Artificial light	Too little	1	2	3	4	5	6	7	Too much
Glare from lights	None	1	2	3	4	5	6	7	Too much

Comments about lighting conditions

Overall comfort

All things considered, how do you rate the overall comfort of the building environment?

Please tick

Unsatisfactory	1	2	3	4	5	6	7	Satisfactory

Comments about comfort

Productivity at work

Please try to evaluate this building with respect to your experience of using buildings in general

Please estimate how you think your productivity at work is decreased or increased by the environmental conditions in the building?

Please tick one point on the scale

Productivity Decreased by	-40% or less	-30%	-20%	-10%	0	+10%	+20%	+30%	+40% or more	Productivity Increased by
	1	2	3	4	5	6	7	8	9	

Comments about productivity

Health

Do you feel less or more healthy when you are in the building?

Please try to evaluate this building with respect to your experience of using buildings in general

Please tick

Less healthy	1	2	3	4	5	6	7	More healthy

Comments about health

Personal control

How much control do you personally have over the following aspects of your working environment…?

Please tick each scale

Importance of control *Please tick if important to you*

										Importance of control
Heating	No control	1	2	3	4	5	6	7	Full control	1
Cooling	No control	1	2	3	4	5	6	7	Full control	1
Ventilation	No control	1	2	3	4	5	6	7	Full control	1
Lighting	No control	1	2	3	4	5	6	7	Full control	1
Noise	No control	1	2	3	4	5	6	7	Full control	1

Response to problems Have you ever made requests for changes to the heating, lighting, ventilation or air-conditioning/cooling (if you have it)...?

Please tick

Yes [1] [2] No

Please give brief details

If yes, how satisfied in general were you with the ...?

Speed of response

Please tick

Unsatisfactory overall [1] [2] [3] [4] [5] [6] [7] Satisfactory overall

Effectiveness of response

Please tick

Unsatisfactory overall [1] [2] [3] [4] [5] [6] [7] Satisfactory overall

Effect on behaviour Do you change your behaviour because of conditions in the building ...?

Please tick

Yes [1] [2] No

If Yes, please give examples. Please note: all responses are treated as completely confidential. Identities of individuals are never revealed.

Travel to work

Please estimate your journey times ...

Journey to work		Time Hours : minutes	Journey home		Time Hours : minutes
Best case	Journey to work		Best case	Journey home	
Normal	Journey to work		Normal	Journey home	
Worst case	Journey to work		Worst case	Journey home	

Post or zip code What is your home post or zip code (or the place where you normally start your journey to work if not home) ...? Postcode

Mode of travel

For your **journey to work only**, how do you normally travel ...?

	Please tick those which apply	**Main mode** *Please tick one*
Walk	1	1
Cycle	1	1
Bus	1	1
Train	1	1
Car (as driver)	1	1
Car (lift or car share passenger)	1	1
Motor cycle (solo)	1	1
Motor cycle (as passenger)	1	1
Tram / Trolleybus	1	1
Ferry	1	1
Other (please specify)	1	1

Main mode *means the journey mode by which you travel the longest distance*

Please specify if Other

Have you any comments or observations on your journeys to work and home, especially with respect to how they affect your work ...?

Comments on journeys to work and home from work

Thank you for your help If you have further comments on the topics raised, please add them on a separate sheet.. Please leave the questionnaire in a prominent place, and it will be collected later today.

Letter to Head Teachers x4

Institute of Energy and Sustainable Development
Queens Building
The Gateway
Leicester
LE1
9BH
Tel. 0116 255 1551
Ext. 6847
Mobile. 07789 991685

December 17th, 2010
Dear Mr Campbell,

My name is Michael Roberts and I work at the Institute of Energy and Sustainable Development (IESD), De Montfort University (DMU). My department consists of an extensive multi-disciplinary team of researchers focusing on environmental, economic and social research problems.

My PhD, funded by the Engineering and Physical Sciences Research Council (EPRSC) and the Pilkington Energy Efficiency Trust (PEET) will examine the first four BSF Schools in Leicester. In the New Year I hope to begin the first stage of my research evaluating the *perceived* performance of the new buildings.

The literature review I conducted in my first year has identified the importance of using a 'tried and tested' methodology when conducting extensive building evaluations. For this reason, and with the approval of my supervisory team, I have elected to use the Building Use Survey (BUS) licensed through the Useable Buildings Trust (UBT). This particular survey was chosen because the results and data analysis are automatically generated and benchmarked across an existing database of over 400 public and private sector buildings. I would therefore like to ask permission to carry out this research at your school and can confirm each questionnaire takes approximately 5 to 10 minutes to complete and is designed for adult users of a building. Please find enclosed an example questionnaire, the summary results, my PhD profile and a disclaimer sheet.

I hope to complete the survey as soon as possible with minimum disruption to the school. It has therefore been suggested that the questionnaire *might* be filled out either at the start of next term, one day before the young people return, or during an Inset Day, also when the young people are not there. If neither option is possible then we can arrange another time when I can personally distribute the questionnaires and answer any questions staff may have.

If you would like to arrange an appointment to meet so that we can discuss these matters please do not hesitate to contact me via email or telephone, 07789991685.

Merry Christmas and a Happy New Year,

Yours sincerely,

Michael Roberts

Reminder Correspondence

Institute of Energy and Sustainable Development
Queens Building
The Gateway
Leicester
LE1 9BH

Tel. 0116 255 1551 Ext. 6847
Mobile. 07789 991685

July 11th 2011

Dear Mr Campbell,

My name is Michael Roberts and I am PhD research student at the Institute of Energy and Sustainable Development (IESD), De Montfort University (DMU).

I have been researching the four BSF Phase 1 Schools in Leicester for 18 months.

I have now successfully completed "Occupancy Evaluations" for which has involved distributing Standardized Building Questionnaires - see example enclosed.

I was hoping to handout and collect questionnaires to staff at Fullhurst before the end of the summer term so that I could write my report to the council over the summer. Do you think this will be possible?

It has also been suggested that where response rate is low, less than 20 questionnaires returned, an INSET day may provide a good opportunity for staff to complete the questionnaire without undue hassle or inconvenience.

I do not have a contact name for the Business Manager at which is why I am writing to you in person directly. I hope you can help.

With kind regards,

Michael Roberts

mroberts@dmu.ac.uk

07789991685

Instructing the Online Survey at School D

Dear Staff at

My name is Michael Roberts and I am researcher from De Montfort University.

My University Profile Page: http://www.iesd.dmu.ac.uk/staff/students/michael_roberts.php

I am looking at the quality of facilities in the first 4 BSF schools in Leicester.

1. Fullhurst :
2. Beaumont Leys: http://homepage.mac.com/aleaman2/1128/index.html
3. Soar Valley: http://homepage.mac.com/aleaman2/11282/index.html
4. Judgemeadow:
   http://macmate.macace.net/~adrian.leaman@macace.net/11283/index.html

If you click on the links above, you will see the results of Beaumont Leys, Soar Valley and Judgemeadows, all “new build” projects.

I am very interested to collect information about Fullhurst, which was a refurbishment so that I can compare the performance of all four schools.

I have now created an online questionnaire which you can complete without the inconvenience of a paper equivalent. The link is below.

Online Questionnaire http://www.usablebuildings.co.uk/Q1128/TwoPageStandard.html

If anyone wishes to contact me about my research, please do not hesitate to contact me on:

mroberts@dmu.ac.uk

Mobile: 07789991685

I would like to now thank you all for taking the time to contribute to my research, which hopefully will allow both current and future school buildings to improve.

Yours faithfully,

Michael D Roberts

Original PhD Description

De Montfort University
Institute of Energy and Sustainable Development

A Mixed Methods Approach to the Post Occupancy Evaluation of Low-Energy Schools

PhD Studentship

The Institute of Energy and Sustainable Development (IESD) is a research institute concerned with the environmental quality of the built environment. The aim of our multi-disciplinary research is to make a worthwhile and significant contribution to sustainable development through research, consultancy and education. Research disciplines draw from both the physical (e.g. engineering) and social (e.g. psychology) sciences.

Applications are invited from well-qualified, committed and highly motivated individuals to undertake an Industrial CASE Studentship, sponsored by the Modern Built Environment KTN, in the area of post occupancy evaluation of low-energy schools. The research will focus on the post occupancy evaluation of the environmental performance and operational efficiency of four Leicester City schools that have been rebuilt and / or refurbished under the Building Schools for the Future (BSF) programme. The successful applicant will work closely with Leicester Miller Education Company; the organization responsible for delivering and maintaining all 16 BSF schools in Leicester. The research will involve the collection and analysis of quantitative data; from Building Management Systems and qualitative data; from interviews, observations and surveys.

The study is required to provide:

- a comprehensive understanding of the operational effectiveness of the school control strategies and systems (automatic and manual) in particular human interactions,
- an analysis of the environmental performance of the four schools
- a framework for the future post occupancy evaluation of BSF schools,
- recommendations for the design, commissioning and operation of the 16 schools to be built in Leicester under the next waves of the BSF programme.

Applicants should have a good undergraduate or master's degree. Due to the multi-disciplinary nature of the research, requiring a mixed methods approach, a range of different academic backgrounds will be considered. The successful candidate will have knowledge and/or experience of the use of qualitative and quantitative research methods. The candidate will also have strong IT skills, ideally experience of programming using e.g. SPSS, Matlab, BASIC, or an equivalent, or be prepared to undergo training. Individuals must have a genuine interest in the post occupancy evaluation of buildings, including both environmental and social performance and behaviour. The candidate must be able to work in a self-directed manner yet have the inter-personal skills to interface with the larger research team as well as the occupants of schools including teachers and pupils. Good organisational and research skills are essential.